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The Eightieth Meeting of the American Astronomical Society

By C. M. HUFFER

The eightieth meeting of the American Astronomical Society, which was held in New Haven, Connecticut, from December 28 to 31, 1948, proved that a large meeting of the Society could also be an intimate one. Dr. Brouwer and his staff from the Department of Astronomy were hosts and had made reservations for rooms in Timothy Dwight College—a New England style dormitory unit of Yale University. This College, a large quadrangular arrangement of dormitory rooms built around a central lounge and refectory, served as informal meeting place for the astronomers assembled. One member of the Yale staff remarked that she was glad to be able to get inside the College, since during the year only male students are admitted. The general opinion seemed to be that the success of a meeting depends largely on everyone being together for informal discussions—and this meeting was highly successful in that regard.

The meeting started with the Council meeting which began at three o'clock in the afternoon and finished just before midnight. Meanwhile astronomers and their guests were assembling from all over the world —at least there was one member from Australia and one from Europe. The rest were of course from the United States and Canada. The informal open house was merely an opportunity to meet old friends and make new ones.

The formal sessions began on Wednesday morning at nine in the W. L. Harkness Hall on the Yale campus. The meeting room was a large, high-ceilinged room finished in dark oak which seated comfortably more than 200 persons. There were two criticisms of this room; the blackboard was not sufficiently illuminated, and the three doors into the hall admitted too much noise from outside. The acoustics were fair, and it was not too difficult to hear; but the length of the room illustrated the necessity that authors plan their slides for an ever-increasing number of auditors who would like to be able to read the screen as well as hear the speaker from the rear of a large room.

The papers could have been grouped into about four categories. They began with mathematical subjects, including three whose authors were from the host observatory with papers on Yale investigations. Then came theoretical papers on stars, clusters, and nebulae of a highly technical nature. About twenty papers were presented the first day. It

seemed impossible to finish the program at that rate; so it was decided to hold simultaneous sessions on Thursday morning. Consequently a division was made of papers dealing with spectra in one room and with general subjects in another, with a request made to the membership of the Society to write an expression of opinion regarding future handling of the program. To divide or not to divide—that is the question.

Thursday afternoon three invited papers on micro-wave astronomy were presented. Professor Burrows of Cornell, who had selected the authors and their papers, presided at the session. The first paper on the measurement of extra-terrestrial radio wave emissions was given by Dr. John P. Hagen of the Naval Research Laboratory. He was followed by Dr. Ralph E. Williamson of Canada who spoke on solar radio emission. Canada is a center for meteor observations by radar and also for this newer field of micro-wave astronomy. The final paper by Dr. Jesse L. Greenstein dealt with the origin of galactic radio-noise—a summary of the results of detection of micro-waves from the galaxy which is in amazing agreement with investigations of the structure of the galaxy by photographic and photoelectric methods. This symposium was arranged because it was felt that American astronomers are somewhat behind European astronomers in these investigations and because a new division of the International Astronomical Union has been set up to foster research in this field.

At 3:30 a Teachers' Conference on the astronomy curriculum in American colleges and universities was held. This conference was held in another room, thus permitting the micro-wave astronomers to continue a discussion of the symposium papers. It was very popular, and the room selected was filled to capacity. In fact, a few people, including the Secretary, took this time for a little relaxation before dinner because of the necessity of standing during the conference. It was announced during the conference that the Council of the Society had appointed the following new members of the Teachers' Committee: Freeman Miller, Chairman, University of Michigan; Thornton Page, University of Chicago; Victor Goedicke, Ohio University; John Streeter, Vassar College; and Fred Whipple, Harvard, representing the Council.

The Society dinner is always the high-light of a meeting. This one was no exception. An excellent turkey dinner was enjoyed by all before settling down to a series of talks which was unique, due to the fact that three speakers made two speeches each. Dr. Bart J. Bok of Harvard was toastmaster—the so-called "loud speaker."

Dr. Shapley announced the election by the Council of two new Patrons of the Society. Judge Henry S. Hulbert and Dr. George Russell Agassiz were elected because of their great interest in astronomy and assistance in building up the departments of astronomy at the University of Michigan and at Harvard. It is hoped that the Council will elect other Patrons of the Society at coming meetings.

Dr. Struve announced that the Council had decided that the third Russell lecture would be given at the 81st meeting in Ottawa next June and that Dr. S. Chandrasekhar had been selected as the lecturer. A telegram of acceptance was received by Dr. Chandrasekhar just after the dinner was concluded.

Dr. Struve then read the list of nominations for officers of the Society selected by the nominating committee and approved by the Council for vote at the summer meeting. Dr. Alfred H. Joy received the nomination for President. Dr. Struve also described the Siberian meteor fall of February, 1947, as reported in the *Russian Astronomical Journal*. Since this fall had only been described in Russian, it was of great interest to learn about this unusual fall of a meteorite which bounced off the surface of the earth as a billiard ball is caromed off the side of the table.

Dr. Brouwer finished the first round by asking for contributions to buy photographic plates for the observatory in Heidelberg, Germany. The acoustics in the dining room were somewhat bad because of the high ceiling and the length of the room. A system of signals had been arranged to notify the speakers when to talk louder. Brouwer was greeted with a frantic waving of napkins from one end of the room.

Dr. Greenstein spoke between rounds as the West-coast representative. He brought greetings from Pasadena, then went on to report that the new 48-inch Schmidt telescope is perfect and that a limiting magnitude slightly fainter than 20th will probably be reached. He also reported that the fate of the 200-inch telescope is still to be decided; that the account in *Time* was probably somewhat too pessimistic, and that the mirror is probably good enough at present for use with the spectrograph and that the photographic images are sometimes very good and at other times poor because of the temperature response of the various parts of the mirror. He concluded that "at present the mirror is better than the seeing."

Then began the second round. Shapley talked about the history and organization of the IAU; Brouwer reviewed the status of the computations of minor planet orbits and ephemerides and reported on the projects planned for building zenith tube photographic telescopes; and Struve ended the program with an account of the difficulty of selecting a place to hold the 1951 meeting of the IAU.

This account would be incomplete without a mention of the weather. When we arrived at noon on the 28th there was a foot of snow on the ground, but the sun was shining, the temperature around 40° F, and the weather delightful. That night it began to rain. The Society photograph was taken in the rain on Wednesday noon. The result was that the photographer did not take time to arrange the 154 people in the photograph satisfactorily, so there was a good deal of crowding. If there are wrong identifications or gaps in the identification list, it is because of the difficulty caused by crowding and the fact that every-

body was wearing a hat and coat pulled close to protect himself or herself from the rain. It was still raining when we left New Haven on Friday.

One hundred and eighty people signed the register during the sessions. There may have been some who failed to sign. The attendance was smaller than the attendance at Pasadena, but larger than other meetings with the exception of the Cambridge meeting in 1946. The papers showed that there is still much research being carried on—the new fields being in the application of electronics to astronomy.

The resolution of thanks read by Mrs. Charlotte Sitterly at the end of the dinner expressed the sentiments of all present that our hosts had been very successful in making us feel at home by keeping us all together at all times.

The following new members were elected by the Council:

Mr. Stanley Brower, 76 Interhaven Avenue, Plainfield, N. J.
Dr. Donald Cameron, Warner and Swasey Observatory, 1975 Taylor Road, East Cleveland 12, Ohio
Mr. Allan F. Cook II, Princeton University Observatory, Princeton, N. J.
Dr. Richard A. Craig, Harvard Observatory, Cambridge 38, Massachusetts
Dr. John P. Hagen, 3001 North Second Street, Arlington, Virginia
Dr. Harold L. Johnson, Washburn Observatory, Madison 6, Wisconsin
Miss Joyce Marrison, Harvard Observatory, Cambridge 38, Massachusetts
Mr. Robert T. Mathews, Box 8, Wesleyan Station, Middletown, Connecticut
Mr. D. W. R. McKinley, 211 Cobourg Street, Ottawa, Canada
Mr. G. E. Moreton, 5516 Corteen Place, North Hollywood, California
Mr. H. Malcolm Priest, 166 North Dithridge Street, Pittsburgh 13, Pennsylvania
Dr. Anders Reiz, Warner and Swasey Observatory, 1975 Taylor Road, East Cleveland 12, Ohio
Mr. Malcolm P. Savedoff, 375 East 205th Street, New York 67, New York
Mr. Malcolm M. Thomson, 209 Gail Avenue, Ottawa, Ontario, Canada
Mr. William Mayo Venable, 6111 Fifth Avenue, Pittsburgh, Pennsylvania

The following invitations have been accepted for future meetings:

June 20-22, 1949	Ottawa, Ontario, Canada.
December, 1949.	Tucson, Arizona.
Summer, 1950.	Bloomington, Indiana.

WASHBURN OBSERVATORY, MADISON, WISCONSIN.

A Systematic Search for Novae

By KARL G. HENZE

A nova is a star whose luminosity increases suddenly (usually in a matter of hours) by a factor of the order of 10,000. The brightness of the star then begins to decline, first rather rapidly, later on more gradually, and in a few years returns to its pre-outburst luminosity. It is now fairly well known that this increase in the star's luminosity

is due to sudden increase of its size; *i.e.*, to a sudden expansion. However, the cause of such an expansion is still unknown, since these stellar explosions are rare events and only a few have been thoroughly investigated with spectrographs of high dispersion.

It is obvious then that a search for novae should be organized in such a manner that brighter novae are discovered at the earliest possible moment. In addition, it should be conducted systematically so that it will eventually supply reliable statistical data.

In the past, few attempts have been made to discover novae systematically. Those which have come to the author's attention may be listed as follows:

1. Early naked-eye observers. Several individual astronomers have kept close watch on the Milky Way constellations in order to recognize any naked-eye novae that might appear.

2. Bailey's inspection of Harvard plates.[1] Fourteen novae were discovered by superimposing and inspecting 2098 plates of Milky Way fields.

3. Harvard's novae spectrum patrol.[2] During the past decade, Harvard has been conducting a search for novae in special regions by means of objective prism spectra.

4. The AAVSO program.[3] The Nova Search Committee of the American Association of Variable Star Observers has proposed a visual search program in which amateur astronomers would participate, each volunteer searching a small area of the sky.

5. Zwicky's search.[4] Zwicky has been conducting a nova search with the 18-inch Schmidt camera at Palomar Mountain.

This paper is a preliminary report on the program organized at the Leander McCormick Observatory and carried out for 11 months. As will be seen in what follows, the present plan provides for the immediate discovery of brighter novae with a minimum of effort and for the accumulation of statistically sound observational material.

Statistical Data

In order to plan an efficient search program we should take into consideration: a. the frequency of the appearance of novae, b. the distribution of novae over the sky, c. the character of light curves of novae near maximum brightness, and d. the distribution of novae by apparent magnitudes. Various lists, especially those published by McLaughlin[5] and Stratton,[6] have been used for this purpose.

[1] S. I. Bailey. The Number and Distribution of Novae. *P. A.*, **29**, 554, 1921.
[2] *HAC*, 439, November 15, 1937.
[3] The Search for New Stars. Nova Search Committee, AAVSO. *Sky and Telescope*, VI, 12, 1947.
[4] C. F. J. Overhage and F. Zwicky. Some Magnitudes of Nova 618.1936 Aquila (I). *PASP*, **48**, 321, 1936.
[5] Dean B. McLaughlin. The Space Distribution ofNovae, *A. J.*, **51**, 136, 1945.
[6] F. J. M. Stratton. Novae. *Handbuch der Astrophysik*, VI, 254-5, 1928, VII, 671, 1936.

To date two estimates of the frequency of novae have been published. The first was that of Bailey from his search of Harvard plates. Fourteen novae were discovered in a survey which represented a biweekly check down to magnitude 9.0 over a period of 1.6 years. Extrapolating these results by assuming that all novae brighter than a certain magnitude were discovered in his search and that the number of novae brighter than a given limit increases in the same ratio as do all the stars, Bailey estimated that about 27 novae brighter than magnitude 9.0 must occur every year and that one or two 6th magnitude novae probably occur yearly. Making somewhat similar assumptions, but basing his data on all the novae so far discovered, McLaughlin has recently (1939) concluded that about 16 novae brighter than magnitude 9.0 occur each year. This would give about one nova per year brighter than magnitude 6.0 and about 2.5 brighter than magnitude 7.0. A similar discussion reaching somewhat the same conclusion appears later in this paper.

Figure 1 shows the distribution over the sky of novae discovered up

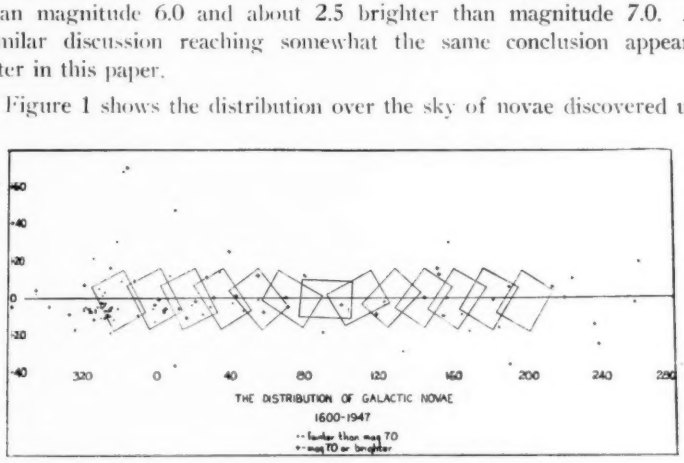

FIGURE 1

to the year 1948. There are two chief characteristics of this distribution.

1. Concentration to the galactic plane. Of all novae, 67% occur with 10° of the galactic equator and 96% within 40°. This concentration is to be expected since novae are known to be distant objects and will thus tend to outline the flattened form of our galaxy. In addition to this apparent concentration, it is probable that there is a real concentration due to the dynamical properties of our galaxy, but ignorance of space motions of novae prevents further discussion of the matter.

The observed distribution may possibly be affected by a more intensive watch for novae along the Milky Way, but the effect of this selection is probably small. The fact that the concentration persists marked-

ly for the brighter novae, for which, presumably, the effect of selection must be smaller, indicates that the concentration is real. The small number of southern observers influences the distribution in latitude very little. The predominance of novae in southern latitudes may be attributed to the sun's being situated slightly north of the galactic plane.

2. Concentration towards the longitude of the galactic center. This concentration is to be expected from our knowledge of galactic structure. However, the distribution is considerably affected by lack of uniform observation. Taking for the longitude of the galactic center the value of 327°, we find that 53 novae were observed in the 82° sector between longitudes 327° and 49°, while there were only 25 novae in the corresponding sector between longitudes 327° and 245°; this lack of symmetry is probably due to the smaller number of observers in the southern hemisphere. The cluster of faint novae in Scorpius and Sagittarius may be likewise partly attributed to a more intense search for novae in this region (see Harvard plan described above) in which the frequency of novae is expected to be the greatest.

The small concentration of novae in the direction of the anti-center may well be accidental.

The light curves of novae near maximum must be considered because the probability of finding any single nova depends, in part, on the rate of decline of its brightness immediately following maximum. Table I lists 62 stars for which reliable figures are available for the time it

TABLE I

RATES OF DECLINE OF NOVAE

No.	t_1 da.	t_2 da.	t_3 da.	No.	t_1 da.	t_2 da.	t_3 da.
1	0.5*	(4)	6	25	(6.0)	16	32
2	1.3*	4	(7)	26	6.4	16	33
3	(1.5)	4	(7)	27	6.4	(17)	34
4	1.6	4	8	28	8.0	20	37
5	1.9*	4	9	29	8.0	20	37
6	2.0	(5)	9	30	8.8	(22)	38
7	2.0	5	10	31	8.8	22	(42)
8	2.4	5	10	32	10	22	44
9	2.4	6	13	33	10	25	48
10	2.8	6	13	34	10	25	50
11	(3.0)	7	16	35	11	25	60
12	(3.0)	8	17	36	12	28	70
13	3.2	8	20	37	12	30	75
14	3.2	8	21	38	12	30	80
15	3.2	9	(22)	39	(13)	31	85
16	3.6	(10)	22	40	18	45	100
17	(4.0)	10	(23)	41	18	45	100
18	4.0	10	25	42	20	50	150
19	4.0	10	26	43	27	67	150
20	4.0	12	27	44	28	70	170
21	4.8	12	(30)	45	28	70	180
22	4.8	(14)	30	46	32	80	300
23	5.6	14	31	47	32	80	320
24	5.6	14	32	48	40	100	350

No.	t_1 da.	t_2 da.	t_3 da.	No.	t_1 da.	t_2 da.	t_3 da.
49	40	100	400	56	(68)	220	
50	48	120	750	57	80	300	
51	48	120	800	58	88	360	
52	48	120	900	59	120	430	
53	48	150		60	144	1500	
54	(52)	150		61	172		
55	60	200		62	700		

*—these vales of t_1 have been taken from original light curves.

( )—these values are for stars appearing since the publication of McLaughlin's list.

Italic numbers—indicate the median values.

takes a nova to decline by 1, 2, or 3 magnitudes. The intervals of time, t_2 and t_3, for a decline by 2 and 3 magnitudes, respectively, are taken from McLaughlin.[3] Data for a one-magnitude decline were obtained by multiplying t_2 by the factor 0.4. This factor was derived from an analysis of original light curves, and the deviation of individual values of t_1/t_2 from the true values was found quite small.

The study of the rates of decline shows that 50% of the novae decline by one magnitude in at least 10 days, and that very few decline by one magnitude in less than two days. To decline by two magnitudes, 50% of the novae require at least 25 days while none decline by two magnitudes in less than four days. For a decline of three magnitudes, no nova has taken less than six days.

Table II shows the observed distribution of novae by apparent magnitude at maximum brightness. The maximum frequency of novae falls

TABLE II

DISTRIBUTION OF NOVAE BY APPARENT MAGNITUDE AT MAXIMUM

m	No.	No. brtr. than	Ratio of Inc.	m	No.	No. brtr. than	Ratio of Inc.
$m < 0$	1	1		$7 \leq m < 8$	13	53	1.3
$0 \leq m < 1$	2	3		$8 \leq m < 9$	12	65	1.2
$1 \leq m < 2$	2	5	1.7	$9 \leq m < 10$	12	77	1.2
$2 \leq m < 3$	3	8	1.6	$10 \leq m < 11$	10	87	1.1
$3 \leq m < 4$	5	13	1.6	$11 \leq m < 12$	8	95	1.1
$4 \leq m < 5$	8	21	1.6	$12 \leq m < 13$	4	99	1.0+
$5 \leq m < 6$	6	27	1.3	$13 \leq m < 14$	1	100	1.0+
$6 \leq m < 7$	13	40	1.5	$14 \leq m < 15$	2	102	1.0+
				$15 \leq m < 16$	2	104	1.0+

in the magnitude range of 6.0 to 8.0; after this the number of novae in a given magnitude interval begins to drop off. This drop is due partly to a decreasing stellar density in the direction of the anti-center, to the interstellar absorption of light, and finally to the decreasing probability of discovery of fainter objects. For the brighter novae (say, brighter than magnitude 2.0) the chances of discovery are very high, while the influence of the interstellar absorption and space distribution is quite small. Consequently, the true ratio of increase of numbers of novae brighter than successive limits should be approximately equal to or

slightly greater than the observed ratio for brighter novae. The data indicate that this ratio is roughly equal to 2.0, where the successive limits are taken at intervals of one magnitude. Now, if we assume that all novae brighter than magnitude 2.0 have been discovered (5 altogether), and that the influence of light absorption in space is negligible, we come to the conclusion that in 100 years 80 novae brighter than magnitude 6.0 and 160 novae brighter than magnitude 7.0 have occurred. That is, about one nova brighter than 6.0 magnitude and 1.5 novae brighter than magnitude 7.0 occur each year. This is of the same order as Bailey's and McLaughlin's estimates.

Planning of the Program

As has been stated above, a search for novae should be conducted so as to provide statistically uniform material and to discover novae at the earliest possible time. Consequently, it is desirable to photograph the sky every night and inspect the photographs as quickly as possible. These requirements impose definite limitations on the program and the choice of equipment. Such limitations are listed as follows:

1. Choice of instrument. Since a large area of the sky is to be photographed at frequent intervals, one must use a fast wide-angle lens. Experiments conducted earlier at this observatory demonstrated that any 35 mm. camera with a lens f/3.5 or faster may be used, but the 2.4 inch f/1.8 Schneider Xenon lens which belongs to the Observatory proved to be an almost ideal instrument for our purpose. A larger camera will produce photographs on a larger scale, but handling and inspecting of such plates would slow down the work very considerably.

TABLE III

Probabilities of Discovery

No.	Name	R.A. h m	Dec. °	a)	b)	c)	Prob. of Disc. 6.0	Prob. of Disc. 5.0	Prob. of Disc. 4.0
1	Sgtr	18 05	−16	190	34	5.6	0.36	0.71	1.00
2	Serp	18 39	0	218	52	4.2	.48	0.95	1.00
3	Aql	19 14	+16	230	70	3.3	.61	1.00	1.00
4	Cygn	19 55	+31	252	71	3.6	.56	1.00	1.00
5	Deneb	20 52	+46	261	76	3.4	.59	1.00	1.00
6	Ceph	22 20	+57	297	83	3.6	.56	1.00	1.00
7	Cass	0 37	+62	292	69	4.2	.48	0.95	1.00
8	Pers	2 58	+57	248	64	3.9	.51	1.00	1.00
9	Capella	4 29	+46	213	50	4.3	.46	0.93	1.00
10	Auri	5 26	+31	212	47	4.5	.44	0.89	1.00
11	Orio	6 04	+16	194	43	4.5	.44	0.89	1.00
12	Mono	6 40	0	177	34	5.2	.38	0.77	1.00
13	Sirius	7 14	−16	177	31	5.7	.35	0.70	1.00
				Sum—2961					
				Mean—228 da.					
	Rapid						0.49	0.92	1.00
	Regardless of Rate of Decline						0.90	0.99	1.00
	For One Year Over Whole Sky (Rapid						0.18	0.33	0.36
						(All	0.32	0.36	0.36

a) Length of the interval of observation.
b) Number of nights observed.
c) Mean frequency of observation (days).

2. Limiting magnitude. The limiting magnitude should be chosen so that the exposure time is not unduly long and so that the field is not overcrowded with stars. With the f/1.8 camera, it was found that the work can be carried on with the greatest efficiency by limiting the program to stars brighter than magnitude 7.0.

3. Area searched. Ideally, the whole sky should be searched for novae but luckily this is hardly necessary since we have seen that almost all novae occur in low galactic latitudes. Therefore, in order to obtain optimum results with a minimum of effort, a 25°-wide zone along the galactic plane has been chosen for observation. The longitudes observed extend from 328° to 313°. This is determined by the geographical latitude of the McCormick Observatory. The field of our camera covers this zone with 13 plates. Table III lists the data concerning these 13 regions and Figure 1 illustrates their distribution along the Milky Way. The name for each region has been chosen to correspond to the most prominent constellation or star in the region.

The limitation of the search to low latitudes will unavoidably have a statistically undesirable effect on the observed distribution of novae in galactic latitude, but will not affect adversely the distribution in longitude; at least not within the range of longitudes observed.

4. Frequency of the search. It is desirable to conduct the search as frequently as possible. Daily coverage of the sky would make certain that all novae were detected at the earliest time possible, and that no nova which reaches a maximum brightness of at least one magnitude brighter than the limit of the search will escape detection. As far as possible, the regions well situated for observation have been searched every clear night. (Observations have been made during 121 out of the total of 164 clear nights.) However, cloudy weather has limited the average frequency of the search to about one night in three.

Description of the Method of Observation and of the Equipment

Briefly, the method employed in this search was to photograph each observable region during every clear night, develop the films the same night, and inspect them the next morning by means of the projector described below. Enlarged prints of the regions were made so that, when a film was placed in the projector, the projected images could be made to coincide with images on the prints. Any projected image without a corresponding printed image could then be easily identified as a new object.

The equipment used may be described as follows:

1. Camera. The camera used in this program is equipped with an f/1.8 Schneider Xenon lens of 2.4 inches aperture and a focal length of 4.4 inches. The angular dimensions of its field are 26° x 20°; the linear dimensions are 2.0 x 1.5 inches. Both 2¼ x 3¼ cut film and 2½ x 3¼ pack film were used, allowing two regions to be photographed in suc-

cession on one sheet by shifting the plateholder. Twelve-second exposures were made by removing the lens cap, and gave well-defined images of 7.0 magnitude stars.

2. Film. Kodak Super Panchro-Press Type B cut film has been used almost entirely. In the beginning, Agfa and Kodak film packs were tried but gave unsatisfactory results due to poor focus. Considerable difficulty was also encountered with the cut film, which apparently warped in the plateholder with changing temperature and humidity, especially in winter. This was satisfactorily solved by storing and handling the film in an unheated, well-ventilated room. Eastman Kodak D-19 developer was used with a developing time of about 10 minutes.

3. Projector. In order to inspect the films conveniently, the projector of a microfilm reader was mounted on a specially constructed wooden stand (see Figure 2). The enlargement employed was about 9X. Films were viewed by placing them between two cover glasses (hinged with cellulose tape) and inserting them into the field of the projector. The field of the projector could accommodate only one-fourth of the 1.5 x 2.0-inch film at once so that it was necessary to make four separate prints for each region.

FIGURE 2
THE PROJECTOR

4. Prints. Prints were made by the following process. First a positive of the original negative was made, using a contrast lantern slide emulsion. This, in turn, was enlarged, using the projector described above, an effort being made to obtain prints of high contrast

The quality of the prints is extremely important for upon it depends the ease and certainty of inspecting the films. The ideal print should show stars down to a limit slightly fainter than that of the films to be inspected, should be free of dust specks or grain, and the paper should have a dull finish. Difficulties were encountered in obtaining ideal prints and in most cases the prints were retouched to remove images of dust specks. Also a few fainter stars were added in ink. The projected field (8 x 8 inches) was printed on 8-10 Eastman Kodabromide paper (E-5, double weight), thus leaving a margin for notes. In order to check the magnitude limits of the projected film, BD magnitudes of several stars in each region were noted on the prints.

The following are miscellaneous notes on techniques employed:

1. The 2-inch camera, fitted with its own declination axis and circle, was mounted on the declination axis of the 10-inch prismatic camera. The details of this mounting are shown in Figure 3.

FIGURE 3
MOUNTING OF THE 2-INCH CAMERA

2. To avoid the confusion caused by dust specks resembling star images, double exposures of each region were taken. The images were spaced by stopping the clock drive for from 20 to 40 seconds depending on the declination of the region.

3. In checking a region against the print, it was found advantageous to jiggle the print; this "blink" effect facilitated the inspection of plates and prevented confusion between the projected double images and the printed single images.

4. Some difficulty was experienced when slightly overexposed films showed stars fainter than those on the print. Usually the difference in intensity was enough to avoid confusion but in borderline cases it was found advisable to refer to a "check plate." Check plates were made by taking long exposures (1-2 minutes) thus reaching a con-

siderably fainter magnitude than the adopted limiting magnitude. If the questionable image appeared also on check plates taken quite a while previously, it was assumed not to be a new object. Using this method, one may possibly miss an object whose light variation is slow, but novae, almost without exception, develop rapidly in their early stages.

5. When an unusual object was noticed, its position, taken from the Bonner Durchmusterung charts, was compared with the predicted positions of minor planets and the positions of variable stars listed in Schneller's catalog.[7] To date, the only "new" objects detected have been six variable stars, the planet Uranus (three times), and a few double stars producing a varying photographic effect.

Preliminary Results

Over a period of eleven months, from 2 May 1947 to 28 March 1948, 852 plates have been taken of 13 regions in the Milky Way. Of these, 725 plates are of good quality and show sufficiently faint stars to be included in the following discussion. The interval during which each region was kept under observation and the number of nights each region was observed are given in Table III.

Using this material one may gain some idea of the maximum frequency of novae. For this purpose, we may compute, with the material available, the probability of discovering a nova. Then the number of novae which have appeared during the period of observation must be less than the reciprocal of that probability. For instance, if the probability of discovering any 6.0 magnitude nova was ½, and the program was continued for one year without detecting a nova, one may conclude that probably less than two 6.0 magnitude novae occurred in that year.

In estimating the probability of discovering a nova of a given magnitude, four factors must be taken into consideration: 1. the rate of decline of brightness just after maximum, 2. the frequency with which the search is conducted, 3. the probable fraction of all the novae which should occur in the region searched, and 4. the fraction of the year during which the region is accessible for observation. To illustrate, take a hypothetical case. Suppose a 6.0 magnitude nova requires two days to fade below the limit of discovery; that the search is conducted every fourth day; that the area searched should contain ¾ of the occurring novae; and that the region is kept under observation for half a year. Then, during the six months, the probability of discovering a 6.0 magnitude nova which occurs in the area observed is ½. Integrating over the whole sky, we get a probability of ⅜; and over the whole year, 3/16. Thus, the probability of discovering a 6.0 magnitude nova occurring at any point in the sky and at any time of the year is 3/16.

[7] Katalog und Ephemeriden Veränderlichen Sterne für 1941. *Kleine Veröffentlichungen*, Berlin-Babelsberg, No. 22, 1940.

Data from which the first factor may be evaluated are contained in Table I. It is seen that one-half of all the novae take 9 days or longer to fade one magnitude from maximum while only five have declined one magnitude in less than 2 days. Again, no novae have declined two magnitudes in less than four days, and none have declined three magnitudes in less than six days. Accordingly, if we adopt 2, 4, and 6 days as the times of decline thru 1, 2, and 3 magnitudes, respectively, we should arrive at the lower limits of the probability of discovery.

The mean period with which the region was searched has been obtained by dividing the total number of days the region was accessible by the number of nights the region was searched. This mean period is listed in Table III. The use of the mean interval introduces an error discussed more fully below.

The third factor may be determined from the distribution of previously discovered novae. Any distortion of this observed distribution is probably of negligible importance in this problem. Figure 1 shows the area covered by each of the 13 regions. It is seen from the figure that of 40 novae brighter than 7.0 which have appeared, 23 have occurred in the area searched. It will be assumed that the galactic distribution of novae within any given magnitude interval brighter than 7.0 is the same as the distribution for all. Thus the probability of finding a nova occurring in the area searched must be multiplied by 23/40 to find the probability of discovering a nova occurring anywhere in the sky.

It is seen from Table III that the interval during which the area searched was accessible was 228 days, or 0.624 of a year.

In Table III the first two factors have been applied to the individual regions. The weighted mean of the probabilities of discovery for the separate regions was then taken, with the weights assigned according to the extent of the period of observation. The second two factors have been applied to these weighted means by multiplying them by $(23/40) \times 0.624 = 0.36$.

It must be noted that the resulting probability is subject to the following errors:

a. Times of decline through a given range of magnitude have been taken for the fastest novae. For slower novae the probability will be greater.

b. The data in Table I are the times required for the novae to drop the given number of magnitudes from maximum. Actually, there will be some opportunity for discovery before a nova reaches maximum brightness. A rapid nova requires approximately one day to rise from one magnitude below maximum to maximum. However, this is very uncertain and no safe estimate of the corresponding correction can be made, except to say that its over-all effect is to increase the true probability of discovery.

c. The use of the mean interval between consecutive observations instead of the individual intervals introduces an error in the computed probability of discovery. This is illustrated by the following example. Suppose that the sky was searched regularly every three days; since novae require at least four days to decline two magnitudes, the probability of finding a 5.0 magnitude nova will be one. Now suppose that the sky is searched irregularly with a mean interval of three days, but with a few gaps of more than four days remaining unsearched; then it is no longer certain that all 5.0 magnitude novae will be found and the true probability is slightly less than one.

Thus the effect of assuming that the search is conducted at regular intervals increases the computed probability of discovery.

Effects b. and c. tend to cancel each other. The first effect, however, is quite considerable, and we may assume that the probability computed in such a manner is a lower limit of the true probability.

One may roughly account for the first error mentioned above by considering that the probability of discovering a 6.0 magnitude nova which declines one magnitude in 4 days is the same as for a 5.0 magnitude nova which declines 2 magnitudes in 4 days. That is, the probability of discovery is a function of the time during which the nova is brighter than the limit, and not of the magnitude it reaches at its maximum. The probabilities computed in Table III for 5.0 and 4.0 magnitude novae may be applied as well to the 6.0 magnitude novae which remain above the limit for 4 and 6 days, respectively. Referring to Table I we see that, in the past, 10 novae declined one magnitude in less than three days. Approximately, we may assume that the average probability of discovery of this type of nova is equal to that of a nova which remains above the limit for two days; *i.e.*, 0.49 (see Table III). Fourteen novae have declined one magnitude in from 3 to 6 days, and 38 in 6 days or longer. Let us take the probability of discovery of these two groups as 0.92 and 1.00, respectively.

Taking a weighted mean and assuming that the distribution of the rates of decline in Table I is the true distribution, we find that the probability of discovering any 6.0 magnitude nova occurring in the region searched, regardless of the rate of decline, is about 0.90.

Applying the same reasoning to 5.0 magnitude novae we get a probability of 0.99.

To obtain the probability of discovery over the whole sky and the whole year, these figures must be multiplied by $23/40 \times 0.624 = 0.359$.

To summarize the results set forth in Table III: during this search we should have discovered 0.18 of the rapid 6.0 magnitude novae, 0.33 of the rapid 5.0 magnitude novae, and 0.36 of the rapid 4.0 magnitude novae appearing over the whole sky and throughout the entire year. Including novae of all rates of decline, the corresponding figures are 0.32, 0.36, and 0.36. Since less than one nova was found, this sets

upper limits of 5.7 rapid 6.0 magnitude novae, 3.0 rapid 5.0 magnitude novae, and 2.8 rapid 4.0 magnitude novae per year. If all novae, regardless of rates of decline, are considered, these upper limits become 3.1, 2.8, and 2.8 novae per year, respectively. These are in general agreement with the estimates of Bailey and McLaughlin.

It is not worth discussing the probability of discovery for novae fainter than magnitude 6.0, because the necessary data are too meager. The probability of discovering such novae, especially the slower ones, should be quite considerable, though, of course, it will be less than that for 6.0 magnitude novae, and will approach zero for 7.0 magnitude novae.

An observational check of the effectiveness of our program is provided by the number of variable stars and planets detected during the search. To insure that the check be a fair one, we had avoided any prior knowledge of the positions of such objects. Schneller lists seven variables which should have been detected in the course of this survey; of these, six were found.* The variable U Cygni, which was missed, underwent a rather slow rise to maximum and was mistaken for a non-variable star. The planet Uranus was "discovered" on three occasions. At magnitude 6.3 it was an object so outstanding as to indicate that any other equally bright object could not possibly have been missed.

Conclusion

In conclusion it may be said that it is highly desirable that a number of observers cooperate in a program similar to the one outlined here. The equipment is fairly simple and relatively inexpensive, and the program can be carried on with a minimum of effort. The important part of the program is to photograph the selected regions every clear night and inspect the films as quickly as possible. The scope of the survey could be greatly increased if observers in southern latitudes could be enlisted.

I am deeply indebted to Dr. A. N. Vyssotsky, who suggested the plan for this search and inspired me to undertake it. My appreciation is due to Dr. H. L. Alden, director of the observatory, whose constant interest in the program and material support given to it assured its success. Thanks are due to Dr. E. R. Dyer for so frequently discussing with me the various problems of this undertaking.

*Originally 16 objects with maxima brighter than magnitude 7.0 and minima fainter than magnitude 8.0 were selected as "detectable variables." However, a color correction of about one magnitude for red variables appeared which cut the list of 16 variables to seven.

Leander McCormick Observatory, University of Virginia, June, 1948.

William Gaertner
1864 - 1948

By R. T. O'CONNOR

William Gaertner, instrument maker, died at his home in Wilmette, Illinois, on December 3, 1948, at the age of 84.

Mr. Gaertner was one of the pioneers of the instrument industry in the United States. His firm, originally known as Wm. Gaertner & Company and later becoming The Gaertner Scientific Corporation, was founded in 1896 at a time when very few scientific instruments were manufactured in this country. His enthusiastic interest in all kinds of scientific instruments and his untiring efforts to achieve greater accuracy and better performance gave his company its distinctive character. His willingness to undertake difficult assignments brought the best inventive minds of the nation's laboratories to his door.

A complete list of all the different types of instruments made by him or under his direction would require several columns of this journal. The story behind them involves the successes and failures of many of our famous men of science.

Mr. Gaertner was born in Meresburg, a small city near Magdeburg, Germany. At the age of 16 he was apprenticed to an instrument maker in nearby Halle, where he remained for four years and learned the fundamentals of his trade. Following this, he augmented his formal education by attending a technical school for instrument makers in Berlin. Then for a period of about five years he broadened his experience by taking short periods of employment as an instrument maker with various important firms of that day. Among these were Appel & Company of Göttingen, F. W. Breithaupt and Sons of Cassel, A. Repsold and Son of Hamburg, and Kraft and Son of Vienna. During this interval he also spent short periods with instrument houses in London and Rotterdam and at the University of Prague.

In 1889, with this extensive experience to rely upon, Mr. Gaertner came to the United States where he was immediately hired by Buff and Berger of Boston, manufacturers of surveying instruments. After about a year with this firm he was employed by the U. S. Coast and Geodetic Survey where his principal assignment was the construction of invariable pendulums according to the design of Professor Mendenhall. In 1893 he left the government service for an extended visit in Germany.

Upon returning to the United States, ostensibly to visit the World's Columbian Exposition in Chicago, he became associated with the Smithsonian Institution in Washington under S. P. Langley as an instrument maker in the astrophysical laboratory. His position at the Smithsonian Institution brought him into close association with many prom-

inent scientists and inventors of that time such as Alexander Graham Bell, Hiram Maxim, Chanute, Rowland, Wadsworth, and others.

In 1895 he joined the staff of Yerkes Observatory but decided a year later to open his own instrument shop in Chicago. He was then 32 years of age.

His small shop, with one apprentice, received its first order from Armour Institute. Shortly thereafter he was commissioned to build an astrophotometer for the University of Wisconsin. Word that a capable young instrument maker had opened a shop in Chicago soon spread and orders came from many nearby institutions. He built physiological and physical instruments for Jacques Loeb, interferometers for Albert A. Michelson, both of the University of Chicago, and astronomical instruments for George E. Hale of Yerkes. Within two years after he opened his shop, instruments were being built for export. Only a short time earlier such instruments had to be imported to this country.

The success, then and later, of his designs of interferometers in accordance with the optical principles set forth by Michelson is clearly indicated by the results of a survey completed in 1947 which indicated that nearly 80% of these instruments currently in use in the United States were of Gaertner manufacture.

Much encouragement was given to Mr. Gaertner during this early period and many customers were referred to him by S. W. Stratton, one time director of the U. S. Bureau of Standards and later president of the Massachusetts Institute of Technology. As a matter of fact, his business was built upon personal recommendations made by satisfied customers to their colleagues.

In 1910 Mr. Gaertner, because of his extensive work with astronomical and astrophysical instruments, was commissioned by the International Geodetic Association to construct a photographic zenith telescope, in accordance with the plans of Dr. Frank E. Ross, for the determination of variations of latitude. In spite of the skepticism of European astronomers as to its feasibility, he undertook the construction of this highly precise instrument and it proved entirely satisfactory. It is now at the U. S. Naval Observatory.

During the first World War Mr. Gaertner acquired the optical shop of his friend, O. L. Petitdidier, thereby adding considerably to the company's facilities. Petitdidier, who had gained prominence both here and abroad as an optician, had long worked closely with Mr. Gaertner and it was undoubtedly his influence which directed Mr. Gaertner's efforts so frequently toward the construction of optical instruments. The company now includes among its products an extensive line of etalons, echelons, Lummer plates, spectrographs, spectrometers, interferometers, monochromators, photometers, measuring microscopes, and similar specialized optical instruments of high precision.

In 1923 the firm incorporated, changed its name to The Gaertner

Scientific Corporation, and entered its newly constructed and larger plant at 1201 Wrightwood Avenue, Chicago, where it is presently located. Shortly thereafter Mr. Gaertner was awarded the Howard N. Potts gold medal by the Franklin Institute "in consideration of his notable achievements as a designer and maker of scientific instruments materially contributing to the success of research in physical sciences."

Mr. Gaertner's interest in astronomical instruments led him to accept orders from all parts of the world for coelostats, heliostats, spectrohelioscopes, solar cameras, prism transits, zenith transits, position filar micrometers, and innumerable special instruments built to customer's specifications for special research projects.

The need for accurate coordinate comparators and linear comparators in astrophysical and spectrographic work carried Mr. Gaertner deep into the problem of manufacturing precision lead screws and he succeeded in developing special methods of cutting, correcting, and testing screws of unexcelled accuracy. His comparator bearing Serial No. 1, constructed early in the century, is still in active use in 1949 at Yerkes Observatory.

During both World Wars all the facilities of the company were devoted to production of testing and measuring instruments for the various services, research laboratories, and essential industries. Mr. Gaertner received many commissions of great trust and secrecy.

In 1924 the company began the manufacture of oxygen regulators for high altitude flying for the air force. A year later production was started on the Estoppey bombsight which was the most accurate sight manufactured up to that time. Since then, many special instruments were constructed for the Army, Navy, Air Corps, and Signal Corps in addition to those regularly manufactured.

In recent years the greatest expansion of educational, industrial, and government research laboratories intensified the demand for certain instruments to such an extent that Mr. Gaertner was forced to suspend the manufacture of some of his more cherished items. Nevertheless, the complete list of precision scientific optical and measuring instruments currently manufactured is probably exceeded by no other firm. A booklet listing and illustrating many of these is available gratis from the company for those who may be interested.

Mr. Gaertner was constantly alert to the changing requirements of science and industry and maintained close personal contacts with the important research laboratories in the country. When his advancing years made traveling difficult, he learned much from his steady stream of visitors whom he plied with endless questions about their work and that of their colleagues.

He was a quiet, retiring man, but possessed an engaging personality which inspired confidence and respect. When presented with drawings of a new instrument design, his quick grasp of the essential details and ability to detect flaws amazed the most experienced engineers. This re-

markable analytical ability remained with him even in his final months when his eyesight had become so poor that he could no longer read the drawings.

He was a member of the American Astronomical Society and the Chicago Association of Commerce, and his firm was a charter member of Scientific Apparatus Makers of America. In the latter organization he took an active part in promoting the development of domestic sources of all kinds of instruments. In 1940, he received the "Pioneer Award" from the National Association of Manufacturers.

Mr. Gaertner was active in the management of the business for more than fifty years. He demanded the best from his employees and won their unfaltering loyalty and unselfish devotion. A recent review of the company's statistics indicates that the average length of employment of those presently employed is something over eight years. 75% of the employees have been with the company more than five years. Some of the master instrument makers who were trained within the firm have been continuously employed for more than 25 years.

It is perhaps not surprising, therefore, that by the terms of his will, Mr. Gaertner, who is survived only by his wife, did what he could for the future security of his faithful employees by providing that the company continue in its present business. It is to be operated in trust for the University of Chicago for a period of not less than 21 years, after which the University will assume ownership of the stock which Mr. Gaertner held. The proceeds are to be used to promote scientific research and technology including the providing of scholarships and fellowships in astronomy and physics.

Mr. Gaertner did much to establish the prestige of American made instruments in competition with those from other countries and to free American Scientists and educators from their dependence upon foreign instrument makers. The instruments bearing his name in the hundreds of laboratories, observatories, and shops throughout the world serve as a fitting monument to his memory.

JANUARY 19, 1949.

Meteor Observations at the Pic-du-Midi Observatory

By SIDNEY VAN DEN BERGH

Meteor observations were made at the Pic-du-Midi high-altitude observatory (2865 meters) between July 13, 1947, and July 26, 1947, with the object of determining: (a) the date on which the Perseid shower began, and (b) the structure of the radiation points active between the dates mentioned above in the area of Per, Cas, And, Peg, Psc, and Tri.

Observations were made with the naked eye,[1] with an 8 x 30 Zeiss field glass,[2] and three F/4.5 cameras.

It was found that the Pic-du-Midi Observatory was eminently suited for meteor work as the night sky is very dark and one usually has rather long periods without clouds (of great importance for radiant determination). Observing conditions are especially fine when there is a "mer de nuages" below the observatory. In summer one can observe much longer on the Pic-du-Midi than in the Netherlands as the nights are longer and the twilight is shorter. (It is possible to start observing one hour after sunset!) As a result of the darkness of the sky, the percentage of 5th magnitude meteors was almost twice that determined from my observations in Holland (Figure 1).

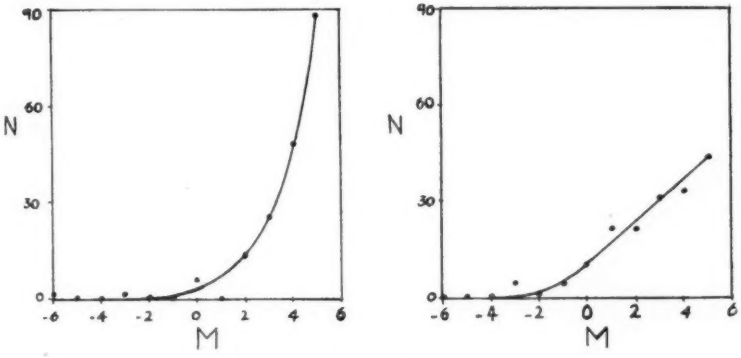

FIGURE 1

PIC-DU-MIDI (FRANCE), ALT. 2865 M. WASSENER (HOLLAND), ALT. 10 M.

PERSEIDS

From the observations it may be deduced with great probability that the shower started in the early morning hours of July 21. During four previous nights the rate was 0; after July 21 the rate was approximately constant at 4. For the critical night of July 20/21, 1947, the rates were:

Time	Rate (corrected)
2130-2230	0
2230-2330	0
2330-0030	1
0030-0130	4
0130-0230	3
0230-0315	4 + 1?

However, observations for the same research project by the Meteor Section of the Netherlands Astronomical Society in Utrecht seem to indicate an earlier commencing date.[3]

On July 14 and July 15 a few meteors resembling Perseids may be seen each year. This time I saw one in UMa on July 14. It seems, however, that these meteors are not connected with the main Perseid

shower. From all good and very good[4] observations and one photographic meteor the following uncorrected radiants could be derived:

		α	δ	
1947	July 20/21	18°	+47°	3 Mts.
	July 24/25	20°	+47°	3 Mts.
	July 25/26	23°	+47°.5	1 + 1 Mts. photogr.

Piscids

During the night of July 24/25 a radiant with a sharp maximum was active at $\alpha = 9°$, $\delta = +21°$ in Pisces, the meteors being mostly of the 4th magnitude. The radiant was still slightly active on July 25/26. On July 24/25, ten out of 38 meteors plotted were Piscids. The influence of the Piscids on the total hourly rate is evident from the Table of Observations.

Table of Observations

Date July 1947	Limits G.M.T.	Visual Period	Mts.	Telescopic Period	Mts.	Photographic Period	Mts.	Plate	Camera Field	Corr. Rate Per Hour
14/15	2230-0130	100 min.	13							8
	0005-0130					85 min.	0	Spectral Gelb	20 x 30°	
	0005-0130					85	1	Spectral Gelb	20 x 30°	
	0015-0130					75	0	Ace Pan	30 x 40°	
16/17	2130-0100	180	25							10
	2130-2215					45	0	Ace Pan	30 x 40°	
	2130-2215					45	0	Spectral Gelb	20 x 30°	
	2240-0110					150	0	Ace Pan	30 x 40°	
17/18	2200-0000	100	16							8
	2200-0000					120	0	Isochrome	30 x 40°	
	2200-0000					120	0	Isochrome	20 x 30°	
19/20	2100-0230	240	24							7.5
	2200-0015					135	0	Super "S" Pan	30 x 40°	
	0030-0230					120	0	Super "S" Pan	30 x 40°	
20/21	2130-0315	275	51							11
	2130-2230					60	0	Super "S" Pan	30 x 40°	
	2245-0305					200	0	Super "S" Pan	30 x 40°	
23	0000-0100	50	4							8
	2015-2150	90	8							7
24/25	2150-2210			20 min.	0					
	2130-2250			20	0					
	2250-0250	180	52							20
25/26	2315-2330			15	0					
	2340-0200	120	14							7
	2340-0210					250	1	Super "S" Pan	30 x 40°	
Total		22h 15m	207	1h 30m	0	23h 30m	2			

Bright Meteors

On July 15 at 0h 39m 35s (±05°) a meteor was seen that became 0 magnitude when exploding at the end of its path. On a photograph exposed from 0h 05m to 1h 30m the double explosion point could be seen at $\alpha = 34°.5$, $\delta = +65°.5$.

On July 26 at 1h 55m a Perseid of —3 magnitude was seen and photo-

graphed. It was possible to make a number of drawings of the long-enduring train as seen through the field glasses. Although the train was approximately 0 magnitude during the first seconds, it did not leave an impression on the photographic plate. After drifting for 4 minutes, it faded below the limiting magnitude of the field glasses.

On July 23 at $20^h\ 19^m$ a fireball of magnitude —6.0 with a companion of 3.0 magnitude was observed. The color of the fireball was light blue. It began at $\alpha = 308°$, $\delta = -2°$ and ended at $\alpha = 309°$, $\delta = -25°.5$.

In conclusion I should like to call attention to the influence of the altitude of the observing station on the number of faint meteors observed, and should like to thank Dr. Baillaud and the other members of the Pic-du-Midi staff for their very kind collaboration.

REFERENCES

[1] For the methods of observation used, see "Het Waarnemen van Meteoren," *Hemel en Dampkring*, **44**, (No. 9) Sept., 1946.

[2] For telescopic observations, see "Some Remarks on Telescopic Meteors," *Journal B. A. A.*, **59**, (No. 1) Dec., 1948.

[3] C. De Jager and A. J. Lehr, *Hemel en Dampkring*, Supplement No. 1, p. 1, Dec., 1948.

[4] For a discussion on the accuracy of meteor observations, see *Journ. B. A. A.*, **58**, (No. 3) April, 1948.

PRINCETON UNIVERSITY OBSERVATORY.

Radio Astronomy and the Cornell Radio Telescope*

The radio telescope has been designed and is being assembled by Cornell engineers. When completed, probably within a few months, it will be used to explore the heavens. Analogous to an optical telescope, it has a 17-foot parabolic reflector mounted on a polar axis which will be driven to follow the motions of the sun and stars. Instead of visual or photographic observation, the information is obtained from a sensitive receiver fed by a small antenna at the focal point of the reflector. The apparatus will be used under all types of weather conditions since radio telescope observations do not require clear skies needed in optical work. The result of the cooperative efforts of Mechanical, Civil, and Electrical Engineers, the telescope will be used in a radio astronomy investigation jointly sponsored by Cornell University and the Office of Naval Research.

Designed to withstand winds up to 60 miles per hour and to track with an angular error of less than half a degree, the telescope will see areas of the sky whose diameter varies from about 2° to 30° depending on the frequency employed. In addition to the usual astronomical

*Contributed by the Cornell University Office of Public Information.

polar and declination axes, there are two other rotations available — one about a vertical axis to facilitate calibration of the antenna, the second the rotation of the reflector about its own axis for polarization studies.

The sun radiates at all frequencies of the electromagnetic spectrum, thus including not only the obvious light and neighboring frequencies, but also, the radio portion of the spectrum. The radiation at the radio frequencies is too weak to be detected by commercial broadcast receivers, but occasionally presents interference in the form of static to the shorter wave bands. This static from the sun and other sources in space, which arrives at the surface of the earth, is the subject of the radio astronomy studies.

The earth's atmosphere is transparent to electromagnetic radiation near the visible portion of the spectrum. Through this window, approximately one decade broad, man has obtained virtually all of his

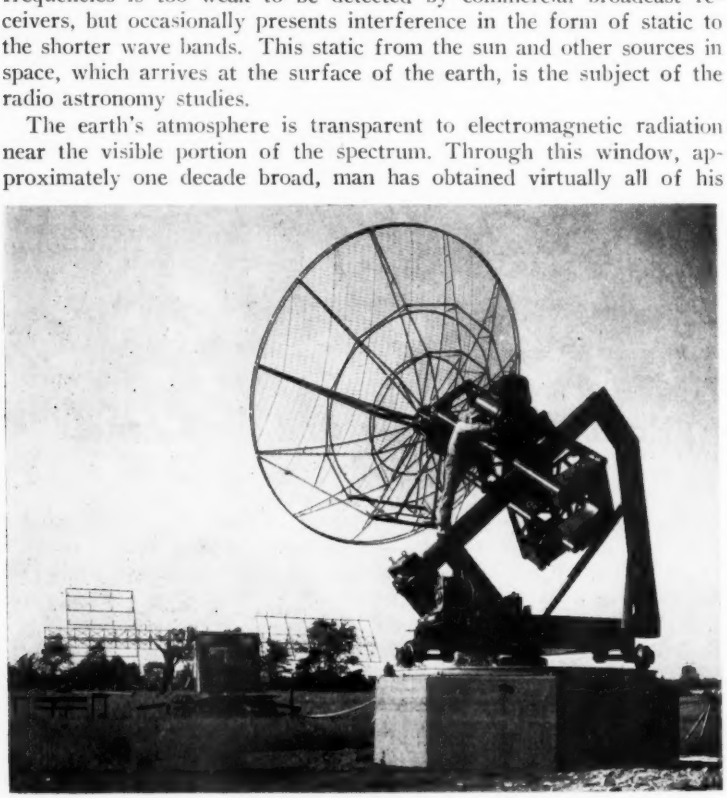

PHOTO BY SCIENCE SERVICE, CORNELL UNIVERSITY

FIGURE 1

The eight-ton radio telescope with its 17-foot saucer-shaped antenna is nearing completion at Cornell University. The machine, one of few in the world, will follow the sun automatically to record solar "noise"—electromagnetic energy which interferes with radio reception at ultra-high frequencies. The saucer, the "mirror" of the apparatus, will collect the inch-long radio waves and pass them along to electronic devices for recording. In the background is a modified Army radar mount with a 200-megacycle receiver with which the Cornell scientists are already making radio-astronomical observations of the sun and other bodies.

knowledge of the universe. A second window exists in the atmosphere. This one is about three decades wide and is located in the shorter wave radio region of the spectrum (20 mc-30,000 mc). It is through this window that the information from outside the earth called static or noise is observed by mean of the radio telescope.

The Radio Astronomy Project at Cornell is conducted in the School of Electrical Engineering where the directional antenna and extremely sensitive receivers are being designed and assembled. At present observations of our sun and galaxy are being made with a modified Army radar antenna mount and a 200 megacycle receiver. This equipment requires that an operator adjust the pointing of the antenna array to follow a prescribed course by means of a manual elevation control and motor driven azimuth control. The acceptance pattern of the antenna is approximately a 15 by 20 degree beam (between half power points) obtained from a 4 by 6 array of half wave dipoles. The initial observations are exploratory in nature, the solar program being aimed at evaluating a daily solar index, indicating the influence of the atmosphere, and surveying the equipment and observational problems. The purpose of the preliminary galactic work is to establish the radio pole of the Milky Way.

To investigate the nature and locations of the extra-terrestrial radiation sources, the radio astronomy project is assembling receivers at 50, 200, 1400, and 3000 mc. These receivers were designed by the engineers on the project to have very high sensitivity, low internal noise, and extreme stability. To indicate the difficulties of design and measurement it might be noted that the noise signal from the undisturbed sun, and the maximum signal from the Milky Way are only one twentieth of the noise generated by the receivers. The measurement of this small signal challenges the engineering skill of the staff. An answer to this challenge has been obtained in two forms, each presently being tested. Qualitative measurements of the solar and galactic noise are now being made at the Airport Laboratory. Absolute measurements will be obtained in time.

The discovery of the existence of extra-terrestrial noise was a by-product of a study by Karl G. Jansky of the Bell Telephone Laboratories, in 1931, of the direction of arrival of high frequency atmospheric static. Jansky noticed a weak fixed source which appeared about four minutes earlier each day corresponding to a fixed location on the celestial sphere. An ingenious analysis determined that the source coincided approximately with the astronomical center of our galaxy, the Milky Way.

From this beginning less than twenty years ago, has sprung the present interest and work in radio astronomy. The British, Australians, Canadians, and French are active in this field. In this country the Naval Research Laboratory, National Bureau of Standards, and Cornell University are engaged in the problem. The interest of the astronomers

and astrophysicists is apace with the development of the radio technique of observation.

As pointed out earlier the radio telescope is analogous to an optical telescope. There are, of course, important differences. While we refer to the instrument as a radio telescope, it is both a telescope and spectograph since it accepts only a bandwidth of frequencies of the order of a megacycle. The radio telescope antenna must for both structural and economic reasons be limited in size to same order as the wave length of the incoming radiation. (At 10 cm wave length the seventeen foot parabola corresponds to about 50 wave lengths.) This accounts for the fact that the radio telescope has an angular resolving power of the order of degrees compared with tenths of a second of arc for optical telescopes.

Astronomical telescopes ordinarily record radiation of all polarization indiscriminately, are sensitive to a large fraction of the optical range of frequency, and use receivers such as the photographic plate which integrate the effects over times the order of hours. In contrast to this the radio telescope has a preference for one plane of polarization, accepts only a small range of frequencies, and integrates the effects over periods of the order of seconds or less. Considering the many significant facts about our universe learned through the optical window of the atmosphere, the new radio telescope offers a rich mine of potential information.

The Optical Work of Charles Tulley

By H. C. KING, F.R.A.S.

In England, the first half of the 19th century witnessed the establishment of many private observatories. This was partly due to the remarkable discoveries of Sir William Herschel, for astronomers were anxious to continue his planetary work and micrometrical measures of double stars. In addition, the work of the Dollonds had placed achromatic telescopes up to 4 inches aperture within the reach of wealthy amateurs. These early achromatics, mounted on ingenious stands and applied to divided circles by Ramsden, Jones, and Troughton were admirably suited for both planetary and double-star work. Unfortunately, the manufacture of English optical glass was in a very backward state. Glassmakers clung tenaciously to their old methods and knew nothing of research; opticians were fortunate if they could obtain 4 and 5-inch blanks free from striae and other defects prejudicial to good definition. For some years the largest English achromatic was the 5-inch which Peter Dollond made for Greenwich Observatory and which was used mainly for observations of the eclipses of Jupiter's satellites.

In 1821, the Council of the newly founded Astronomical Society of London received a letter from Reynier of Neufchatel, Switzerland, to

the effect that a glassmaker named Guinand was able to supply flint blanks up to 12 inches diameter. This advance was due to an improved process of stirring and casting which he, Guinand, had invented. The Council thereupon invited Guinand to submit specimens of his glass, but the samples which arrived were disappointingly small. The largest disc, a 2-inch, was given to Charles Tulley, an optician of Territt's Court, Islington, with instructions to make with it a concave lens suitable for an achromatic object-glass. Tulley effected this and presented to the Council an objective which a sub-committee consisting of Gilbert, J. Herschel, and Pearson considered "trifling" in size but good in performance.

Meanwhile, further flint discs arrived from Guinand, one of which, a 7¼-inch blank, looked so promising as to warrant its working into a component for an object-glass. Tulley had by him a disc of French plate-glass which he worked into a convex lens, but the completed combination was unsuccessful. Tulley now "with a zeal and constancy for which he is entitled to much credit," obtained and worked a second convex component, this time of English crown glass. The resultant objective, of 6.8 inches clear aperture and 12 feet focus was then mounted in a temporary wooden tube at Tulley's house and G. Dollond, J. Herschel, and Pearson spent many hours testing it. The definition of Jupter, Saturn, nebulae in Virgo, and "difficult" doubles like Polaris, γ Leonis, ζ Cancri, and ω^2 Leonis with powers from 200 to 700 was considered extremely good. The observers attributed the good achromaticity to the quality of the flint glass and referred the almost complete absence of spherical aberration to "the goodness of its workmanship." In concluding their report on this lens, the three astronomers paid tribute to "the great pains bestowed on its workmanship by Mr. Tulley."

The Council was now anxious to dispose of the object-glass, but Tulley asked £200 for his work and there was, in addition, the cost of £20. 16. 6. plus 700 francs due to Guinand for the flint blank. The Council considered Tulley's charge excessive, and did not hesitate to tell him so, adding that his figure was discouraging to further experiments. Pearson, however, stepped in, bought the glass outright and so prevented what might have become a serious dispute.

It will be seen from this account that by 1823, Charles Tulley was an optician of no small standing. He had been a Member of the Astronomical Society since its foundation in 1822 and with George Dollond, one of the founders, was always consulted on optical matters. How Tulley came to the Islington business we do not know; presumably he served an apprenticeship under one of the London opticians—perhaps Peter Dollond—and then launched out on his own. It is probable that he set up in business between the years 1775 and 1785, using a room in his own house as a workshop and his garden as an observatory. At that time P. Dollond and Ramsden were at the height of their

business activity, the former producing large numbers of double and triple achromatics, the latter making theodolites and mural circles of a size undreamed of at the beginning of the century. Edward Troughton had joined his brother John in 1770 and when he brought out in 1793 his new improved dividing engine, bade fair to surpass Ramsden. This he eventually did, for Ramsden, whose health was never good, died in 1800 and his successors, Berge and Worthington, were unable to maintain the lead. W. Cary and T. Jones, two of Ramsden's apprentices, were also, by 1800, well established as independent instrument-makers, but Troughton surpassed both. All these great artists, respected and admired for their skill, inventiveness, and business acumen, rose from humble circumstances and Tulley was probably no exception. Never before had the demand for optical apparatus been so great, never the demands on manual and technical skill so great. It was a period calculated to inspire a young and ambitious optician.

With the construction of divided instruments and telescopes so well cared for by Ramsden and the Dollonds, Tulley spent some years manufacturing reflecting telescopes. He had, at least among the London opticians, no serious rivals save T. and W. Harris of Holborn. The latter, together with Cary, Watson, and Cuthbert did not make telescope construction their main concern. We learn of Tulley's earlier work through William Kitchener, an eccentric but ardent collector and user of telescopes, for about the year 1800 Kitchener bought a 7-inch Gregorian from Tulley and two years later a 15-inch Cassegrainian. Kitchener next refers to Tulley's trials with Cassegrainian and Gregorian reflectors following the publication of Captain Kater's paper in the "Philosophical Transactions" for 1813 on their comparative merits. Kater came to the conclusion that a Gregorian gave brighter images than a Cassegrainian of the same size and power in the ratio 20 to 11. In his experiments he had used two telescopes made by a Mr. Crickmore "a self-taught genius." Tulley firmly denied any such difference and told Kitchener that he thought it a pity that Kater had not had an opportunity of seeing really good telescopes. "If Mr. Crickmore with very little practice, has even equalled, much less surpassed, what has been done before, he has been very fortunate indeed." Amateur telescope-makers would probably disagree with this verdict if it were passed today! Tulley then informed Kitchener of the comparisons that Pearson, Kelly, and Arago and he himself made between two 2-foot telescopes, one a Gregorian and the other a Cassegrainian. Both had identical apertures, magnifications, and fields of view, but no difference was noted. Later, Tulley compared two 7-inch reflectors and again found no difference.

Pearson in his "Practical Astronomy," published in 1824, gives figures of a Tulley Gregorian and Newtonian of fairly modest apertures. The Gregorian is of the conventional type established by Short but mounted on an ugly but well-braced altazimuth stand. The New-

tonian is merely a copy of Herschel's smaller stands with a few minor alterations. If these illustrations are representative of Tulley's work it is clear that our optician had introduced, by 1824, no real improvement on the work of his predecessors. From the undated price list which Kitchener published in 1825, Tulley made Gregorians of 2½ inches to 9 inches aperture and charged £7. 7. 0. for the former and £210 for the latter. He lists three Newtonians—a 6.3-inch Herschel type at £100, an "Improved" 7-inch at £126 and a 10-inch at £315. It appears from the eyepieces Tulley provided that he found some difficulty in matching the two Gregorian mirrors; he supplied a maximum power of 350 with his 9-inch Gregorian but 1000 with the 10-inch Newtonian. His mirrors appear to have been worked to an aperture-ratio of F/12 to F/14 after the example of the elder Herschel.

Tulley's work first came into prominence when he made, in 1822, a 3¼-inch F/14 object-glass for Sir James South. This glass was based on the computation given by Sir J. Herschel for an aplanatic doublet and was, at the time, quite novel. Charged with a power of 300 the glass gave excellent results; "what therefore, Mr. Herschel's theory told him would be good, Mr. Tulley's practice has declared so" South wrote. Such was the latter's confidence in Tulley's ability that he entrusted Tulley with the working of two large flint blanks which he received from Paris about this time. The first object-glass, a 5-inch of 7 feet focus, South considered the finest in existence. "Proof of this," he wrote, "will be found in the separation and measurement of the most minute double stars such as η and σ Coronae Borealis, and its sharp definition of the double ring of Saturn, and various others of the most delicate celestial objects." Before parting with it, Tulley and his son compared it with a 6.8-inch Newtonian of 7 feet focus and observed the eclipses of Jupiter's satellites "as well and as long as with the other Telescope." "I believe," Tulley wrote to Kitchener, "that the 7 feet Achromatic is the only Achromatic Telescope of that focus which has been made in this country of 5 inches aperture — the Magnifying powers were from 100 to about 500 times."

South sold the second glass, of 5.9 inches aperture and 8½ feet focus, to W. H. Smythe for £200. South told Smythe that this objective was, in his estimation, Tulley's "chef d'oeuvre." So large an aperture was unique in those days — "I deemed myself fortunate in securing the prize," Smythe records. At his Bedford Observatory Smythe had the glass mounted by George Dollond on a large polar axis, driven by a Sheepshanks "clock" drive. "On repeated trials," Smythe writes, "I find the instrument bears its highest magnifiers with remarkable distinctness, as is especially evinced by the roundness of small discs, the dark increase of vacancy between close double stars, and from particular portions of the moon when dichotomized: I have therefore reason to presume that the curves of the lenses are in exact chromatic and spherical aberration throughout." Upon observations

made with this instrument. Smythe founded his classic, "Cycle of Celestial Objects"—the first book to be written expressly for the amateur astronomer.

When he had completed his catalogue of nebulae and double stars, Smythe parted with his telescope to Dr. Lee who had erected a private observatory at Hartwell House in Buckinghamshire. The two friends continued their work together, assisted by N. Pogson and J. Epps, the former becoming famous for his catalogue of variable stars. This telescope is now in the Science Museum, London. Tulley's largest refractor, the 7-inch, passed from Pearson to Capt. W. Noble, and in 1855 to L. Prince who erected it at Crowborough Hill Observatory.

According to Pearson, Tulley determined the refractive indices of his glasses by a method first practiced in England by L. C. Martin and well-known to the Paris opticians. This was to grind and polish several glasses to the same radius of curvature and then to compare their respective focal lengths when held up to the sun. "After having done this," Pearson writes, "with a specimen of both crown and flint glass, this artist is able to compute his curves and, by his particular dexterity of tact, to work the faces to such perfect figures, that all the sources of error will be cured by him, that art can accomplish with given specimens of glass." The reader will appreciate the immense labour these trial and error methods entailed. We cannot but admire the patience of opticians a century ago and yet deplore the fact that they were apparently content to proceed in this wasteful but time-honoured fashion. This was soon to change owing to Fraunhofer's new conception of refractive index and accurate determination of partial dispersion—but not until halfway through the century. I can best sum up Tulley's method by quoting from the obituary notice to him which appeared in 1833. "It is grievously to be lamented," the author writes, "that much of the labour of this invaluable artist was absolutely wasted, from the impossibility of procuring flint glass capable of forming an object-glass at all, lens after lens having been rejected by him before one could be found of requisite purity, even of moderate apertures." We would add also that many crown-glass components were discarded (though in a lesser degree), for similar reasons.

Charles Tulley was not a member of the Worshipful Company of Spectacle Makers and we are left to only one source of information as to his death—the "Monthly Notices" of the Royal Astronomical Society. He is sometimes referred to as the "Senior Tulley," often as "Mr. Tulley." It is possible, therefore, to confuse his work with that of his two sons, Thomas and William, both of whom assisted their father. The index to the "Monthly Notices" erroneously ascribes the obituary notice to William Tulley, but this elder brother appears in the List of Fellows for February, 1833 and June, 1835, that is, four years after his father's death. The next List, June, 1838, gives the name of Thomas Tulley, who carried on the business after his brother's death

until his own in 1846. After this date we hear no more of the Islington business. To William Tulley falls the distinction of being the first to make (in 1824), achromatic microscope object-glasses; just how much he contributed to his father's success we cannot now tell.

BIBLIOGRAPHY

W. Pearson: "An Introduction to Practical Astronomy," Vol. 1, 1824.

W. H. Smythe: "The Cycle of Celestial Objects Continued at the Hartwell Observatory to 1859, with a notice of recent discoveries, including details from the Aedes Hartwellianae." 1860. "The Cycle of Celestial Objects, for the use of Naval, Military, and Private Astronomers." 1844.

W. Kitchener: "Of Telescopes; being the Result of Thirty Years' Experiments with Fifty-One Telescopes, of from one to nine inches in Diameter." 1825.

J. South: Astronomical Observations made with Herschel's Object-Glass—*Journal of Science*, Royal Institution, No. 26, 1822.

J. W. F. Herschel: "The Aberrations of Compound Lenses and Object-Glasses," *Philosophical Transactions*, 1821.

H. H. Turner: "History of the Royal Astronomical Society," Decade 1820-1830. London, 1923.

C. Tulley: Obituary Notice, *M. R. A. S.*, Vol. 5, p. 386.

T. Tulley: Obituary Notice, *M. R. A. S.*, Vol. 15, p. 261.

"STELLAFANE" 18, SUTTON AVENUE, SLOUGH, BUCKS.

The Planets in March, 1949

By RAYMOND H. WILSON, JR.

NOTE: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac*.

Sun. During this month the sun will progress from 8 degrees south of the equator to 4 degrees north of it, and days will begin to exceed nights in length, for the northern hemisphere. The equinox occurs on March 20 at 5 P.M.

Moon. The phases of the moon will occur as follows:

First Quarter	March	7	7 P.M.
Full Moon		14	1 P.M.
Last Quarter		21	7 A.M.
New Moon		29	9 A.M.

The moon will be at perigee on March 14.

Evening and Morning Stars. Saturn will be easy to see in the evening, while Jupiter will be conspicuous in the southeastern sky just before dawn.

Mercury. At the beginning of the month Mercury will be just past a greatest western elongation. Hence it might be glimpsed in the southeast morning twilight during the first few days of the month.

Venus. Venus will rise only 30 minutes ahead of the sun at the beginning of the month; it will have disappeared in the morning twilight before the end.

Mars. Since it will pass conjunction with the sun on the 17th, Mars will be practically unobservable this month.

Jupiter. By the end of this month Jupiter will be rising at 3 A.M., but a southern declination will hinder its observability.

Saturn. This is definitely the "planet of the month," since it will be just past its closest approach to the earth, and well above the eastern horizon for early evening observation. It will approach very near to Regulus from the northeast but may be distinguished as the brighter star of the pair.

Uranus. At the beginning of the month Uranus will be stationary at a point about 3 degrees north of ζ Tauri.

Neptune. Neptune will be moving northwestward at a position about one-third the way from γ Virginis to Spica. At 10 P.M. on March 15 the moon will pass a half degree south of the planet.

Department of Mathematics, Temple University, Philadelphia, Pa.,
January 9, 1949.

Asteroid Notes

By HUGH S. RICE

The number of well-known asteroids in the official lists for 1947 and 1948 is 1563. In the 1949 series one new asteroid, 1564, has been added. As yet it has no name but only the provisional designation 1936 TB. Not all of the 1564 planets come to opposition in 1949, but approximately 1200 do. For this year the computations are made at the German headquarters in Heidelberg, and the arranging, editing, and printing of the ephemerides are done in the U. S., by coöperation of the Cincinnati, the Yale, and the U. S. Naval Observatories. The Russian astronomers have likewise calculated about the same number of ephemerides, and have published them in a book (with Russian text) similar to the one issued at Cincinnati. Thus there are two sets available. In most cases the ephemerides agree quite closely with one another, but occasionally a considerable discrepancy is found between them. This is not very surprising, inasmuch as certain of the planets have not been observed for some time, and so there is some uncertainty.

We have received word from our astronomical friends in Cairo, Egypt, regarding observations of Pallas in December and January. The apparent path of the asteroid was plotted on a section of the Córdoba charts because of the southern declination. An inspection of a number of observed positions shows that the planet did not follow precisely the predicted course but followed a similar curve which intersected the path as drawn. The observer, Bajocchi, indicated the visual magnitude, which was close to 7, as predicted.

CERES, giant minor planet no. 1, is at opposition February 11, and is in an excellent position for northern observers. During February and March it is retrograding in northern Leo and Cancer. On February 10 and 11 it passes just south of the star 15 Leonis. The photo-magnitude of Ceres is predicted as 7.0, from which we estimate the visual magnitude to be about 6.3. This is very bright for Ceres and if true it could be seen *nudis oculis* under the proper circumstances of an exceptional sky and good eyesight, whereas Vesta is commonly said to be the only asteroid visible to unaided vision. An observer, after having picked up the object and plotted it on an atlas, can follow it for several weeks after the given ephemeris has run out.

[Observed Ceres this evening at $22^h\,20^m$ E.S.T., for the first time at this apparition, with Zeiss 50-mm, from position plotted on Norton's Star Atlas. The planet was about 2° east of Mu Leonis. Identification was immediate, as a check

was afforded by the Beyer-Graff chart. The magnitude (visual) was about 7; and it will become brighter until opposition.]

10 HYGEIA is in Leo and Sextans, with visual magnitude of about 9. 17 THETIS and 349 DEMBOWSKA are both in Leo with visual magnitude of 10. The ephemeris of 349 is taken from the Russian book, and the others from the one published here.

ASTEROID EPHEMERIDES
For 0^h U.T. Equinox 1950

1 CERES			10 HYGEIA		
	α	δ		α	δ
1949	h m	° ′	1949	h m	° ′
Feb. 13	9 37.7	+29 46	Feb. 13	10 52.2	+ 2 30
21	9 30.3	+30 27	21	10 46.5	+ 2 55
Mar. 1	9 23.7	+30 51	Mar. 1	10 40.2	+ 3 25
9	9 18.4	+30 57	9	10 34.1	+ 3 58
			17	10 28.3	+ 4 30
			25	10 23.0	+ 4 56

17 THETIS			349 DEMBOWSKA		
	α	δ		α	δ
1949	h m	° ′	1949	h m	° ′
Feb. 13	11 11.1	+10 21	Feb. 13	11 18.0	+15 4
21	11 5.1	+11 22	21	11 12.0	+15 39
Mar. 1	10 58.1	+12 26	Mar. 1	11 5.4	+16 13
9	10 50.8	+13 27	9	10 58.5	+16 41
17	10 43.8	+14 21	17	10 51.9	+17 2
25	10 37.7	+15 4	25	10 45.9	+17 14
Apr. 2	10 33.1	+15 32	Apr. 2	10 40.8	+17 19

Hayden Planetarium, American Museum of Natural History, New York, January 20, 1949.

Occultation Predictions for March, 1949

(Taken from the *Amerian Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

				IMMERSION				EMERSION			
Date				Greenwich			Angle E from	Greenwich			Angle E from
1949	Star		Mag.	C.T.	*a*	*b*	N	C.T.	*a*	*b*	N
				h m	m	m	°	h m	m	m	°
OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′											
Mar. 10	BD+27°1337		6.4	4 17.1	−1.5	−0.4	66	5 7.2	+0.2	−2.6	325
10	134	B.Gemi	6.5	6 13.4	+0.1	−1.8	124	7 5.4	0.0	−1.1	266
11	λ	Canc	5.9	6 57.3	+0.1	−1.8	128	7 49.5	0.0	−1.3	275
19	32	B.Scor	5.4	6 8.1	−1.2	+0.9	98	7 15.4	−0.9	−0.3	317
19	40	B.Scor	5.4	9 31.1	−0.6	−2.2	174	10 7.5	−2.5	+0.7	228
21	210	B.Scor	6.0	9 29.5	−3.2	+2.7	33	10 5.2	−1.0	−1.8	343

Date 1949	Star	Mag.	Immersion: Greenwich C.T.	Immersion: a	Immersion: b	Immersion: Angle E from N	Emersion: Greenwich C.T.	Emersion: a	Emersion: b	Emersion: Angle E from N
			h m	m	m	°	h m	m	m	°
Occultations Visible in Longitude +91° 0′, Latitude +40° 0′										
Mar. 6	63 Arie	5.2	3 18.2	—0.7	—0.6	67	4 22.5	—0.1	—1.2	266
10	BD+27°1337	6.4	3 51.1	—1.6	—1.1	101	5 5.4	—0.9	—1.7	290
10	134 B.Gemi	6.5	6 25.0	+0.7	—3.5	163	6 58.2	—1.4	+0.1	229
11	λ Canc	5.9	7 6.0	+0.5	—3.0	164	7 44.4	—1.1	—0.5	242
12	90 H^1.Canc	6.1	2 17.9	..	..	42	2 41.5	..	..	6
19	50 B.Scor	6.4	11 36.9	—2.2	+0.1	61	12 32.5	—1.7	—2.2	334
21	210 B.Scor	6.0	8 42.1	—1.4	+1.6	73	9 48.2	—1.0	0.0	312
23	*b* Sgtr	4.6	11 2.7	—0.5	—1.2	150	11 35.6	—2.4	+3.4	196
Occultations Visible in Longitude +98° 0′, Latitude +31° 0′										
Mar. 6	63 Arie	5.2	3 23.2	—0.7	—1.8	104	4 24.2	—0.7	+0.4	229
10	BD+27°1337	6.4	3 57.5	—1.3	—2.9	140	5 3.8	—2.0	0.0	252
11	ψ Canc	5.8	0 48.5	—1.5	+2.5	60	1 49.5	—2.1	—2.2	323
12	90 H^1.Canc	6.1	1 44.0	—1.7	+0.8	92	2 58.2	—1.8	—1.4	312
19	32 B.Scor	5.4	6 9.2	+2.1	—4.3	188	6 30.0	..	..	228
19	50 B.Scor	6.4	11 19.4	—2.7	—0.1	85	12 37.5	—2.0	—1.8	315
21	210 B.Scor	6.0	8 25.2	—0.6	+0.5	107	9 37.5	—1.3	+0.6	282
Occultations Visible in Longitude +120° 0′, Latitude +36° 0′										
Mar. 3	73 Pisc	6.2	2 0.8	—1.3	—1.4	90	3 1.9	—0.5	+1.3	207
6	63 Arie	5.2	2 45.3	—2.0	—0.9	89	4 3.6	—1.4	+0.4	232
6	65 Arie	5.9	3 55.5	—1.3	—2.2	108	4 58.1	—1.1	+0.8	221
10	BD+27°1337	6.4	3 3.0	—2.2	—2.1	135	4 11.7	—2.6	+1.7	240
12	90 H^1.Canc	6.1	1 27.6	—0.4	+2.4	62	2 16.8	—1.4	—1.5	328
19	50 B.Scor	6.4	10 30.3	—1.6	+0.2	110	11 49.7	—1.7	—0.6	304
22	183 B.Sgtr	6.2	13 49.9	—2.2	+0.2	104	15 16.8	—2.2	+0.5	243

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

Quite the most interesting recent event to come to my attention in meteoric astronomy is the announcement of the discovery in northwestern Australia of a probable meteor crater, second in size only to that in Arizona. The first and longer account to reach me is in "Walkabout," the Australian Geographic Magazine, in the November, 1948, issue. This was sent by our member J. Fraser Paterson, Esq., of Broken Hill, Australia, long active in our society. The second is a clipping from an Indian paper, also sent me by one of our members there. Both came only last week, within a day of one another.

The crater is about 2800 feet in diameter and quite circular. It has walls about 100 feet high on the outside and on the inside about 200 feet. The latter are fairly steep. It is situated in the state of Western Australia, 64 miles south of the tiny hamlet of Halls Creek and about 400 miles inland from the coast. Its longitude and latitude are about 134° E and 19° S, respectively. The rimrock is of sandstone, partly drifted over by windblown sand. Inside many trees are growing, some of the dead ones being fully 2 feet in diameter. "The walls of the crater are steep and composed of hard micaceous sandstone, probably pre-cam-

brian. This sandstone is shattered and tilted at various angles outward from the crater." The walls are of fairly uniform height with but one shallow dip.

While the crater appears first to have been sighted by a white man in 1935, a constable whose attention was called to it by a native guide, evidently he did not realize its importance and only recent questioning brought out the fact that he had seen it. The real discovery therefore was by two scientists flying on a prospecting expedition for the Vacuum Oil Company, namely Dr. Frank Reeves and Mr. W. B. Sauve. They at once realized the probable significance of what they saw. As soon thereafter as practicable, they and others succeeded in reaching the vicinity by truck, and going the rest of the way on foot secured a number of excellent photographs both inside and outside. They also had a fine one taken from the plane. Being able to spend only a couple of hours on the spot and being without magnetic equipment, they did not find any meteorites. But this may well be due to the drifting of sand over the older surface, or merely that they had so little time to search. Later, it is understood that a well-equipped expedition will be sent which will make a thorough study and search of the vicinity. After this is done it should be possible to give a definite verdict on the origin. There seem to be no mountains near and, so far as I know, no volcanoes nearer than the East Indies. Nobody could learn of any native legends connected with the crater so that its formation lies probably in the distant past before man inhabited that region, which is at present quite dry, almost semi-arid.

While the subject of meteor craters is being mentioned, I have learned that last summer the American Astronomical Society, at its meeting in California, passed a resolution concerning Meteor Crater, Arizona. As I was not present at the meeting and heard of the resolution only recently, and indeed do not yet have a copy of it, I must reserve a discussion of the matter to a later date.

In Popular Astronomy, **56**, 432 (1948) in these Notes the writer briefly reviewed part of the very important series of papers on the Perseids by Georges Guigay of the Marseilles Observatory. Further remarks will here be made.

Guigay says that, as no means exist of knowing the major axes of the orbits of the Perseids, he decided to calculate the orbits on the following hypotheses, the radiants of course being known. (1) Period of 108 years, (2) parabolic velocity, hence infinite period, (3) period of 54 years. For this purpose he follows in general the method given in my book "Meteors," a method which indeed I had largely adopted from Bauschinger's "Bahnbestimmung." His table of orbits then contains the elements Ω, i, p, e, and ω calculated for 9 dates at 4 or 5 day-intervals, using Denning's radiants. It is surprising how small are the changes in the elements, no matter which period is used. The largest changes come in p and e, but even for the latter, using 54 years, the value is still 0.87. If these 9 orbits are projected on the plane of the ecliptic, they cut in almost the same small area, on all three hypotheses. Projecting the center of this area upward until it cuts the orbit of Comet 1862 III, which it will do as orbit 7 is practically that of the comet itself, this point turns out to have coordinates for 1883.0 of $l' = 28° 57'$, $b' = 65° 15'.1$.

Guigay next discusses the question, assuming that the comet in the distant past actually in part broke up at P, could they not equally well have other radiants. He then develops a method of finding all possible values λ, β of the apparent radiant of a meteor which, issuing from P, could meet the Earth at one of the points in its orbit it will occupy between July 11 and August 19. By a long and complicated method he is able to show indeed that values of λ-$\odot$ and β, which would fit, may be assigned to a variety of orbits which are calculated as examples for

several dates. Quoting his words: ". . . the parabolic orbits of those of long period correspond always to values β and λ-$\odot$ near 38° and —77°; if the radiant is slightly moved from this 'parabolic' position, the corresponding orbit is a hyperbola or an ellipse of short period. This fact permits an explanation of why β and λ-$\odot$ remain always near 38° and —77°, provided that we admit that the breaking up of the comet at point P goes back to a sufficiently distant epoch. In the case of a very old dispersion then the particles thrown into hyperbolic trajectories have gone out indefinitely, and are out of the question, the particles of short period have returned a great number of times to the vicinity of the Earth and have fallen upon it: they are thus accounted for. Besides these particles would frequently come back to the point of dissociation P where the density of the matter is especially great, and they could meet there other particles and be thrown by these shocks into trajectories which no longer meet the Earth's orbit. Only the particles of long period which pass much less frequently in the neighborhood of the Earth and of the point P have conserved their orbits up to our times. But these are the only ones which give the radiants such as λ-$\odot = -77°$, $\beta = 38°$."

Guigay finally attempted to find whether other comets had orbits which passed near that of 1862 III and also had certain other necessary characteristics. As a full discussion would be too long, only his final results are here quoted. In the table he gives for the 5 comets which appeared probable the following: period T in years, shortest distance $\triangle_m$ of their orbits to that of 1862 III, and the true anomaly θ_m of the foot of the common perpendicular upon the orbit of 1862 III.

Comet	T	$\triangle_m$	θ_m
1825 II	∞	0.022	—47°.5
1826 V	∞	0.045	—67.
1877 III	10719	0.060	—58.6
1932 V	302.5	0.071	—51.5
1909 I	123.4	0.029	— 2.8

". . . In the present case, if we remember that, following the perturbations of the planets, the orbits of bodies separated in a distant past can today no longer cut rigorously, we are led to see in the total comets 1862 III, 1825 II, 1826 V, 1877 III, 1932 V, and the current of the Perseids the remains of a comet having undergone such a rupture. The comet 1909 I which did not approach [the orbit of] 1862 III in the vicinity of the point P, but near the perihelion, would be separated from 1862 III subsequently."

The paper which has just been partly reviewed is a thesis presented to the Science Faculty of the University of Paris for the degree of Doctor of Mathematical Sciences. It is 102 pages in length, and represents, so far as I know, far the most complete and thorough study ever attempted upon the Perseid stream. The amount of calculation which must have gone into its preparation is immense, the results most important, and it should be carefully read by everyone interested in the theoretical side of meteoric astronomy.

Members are requested to send in their annual dues to the A.M.S. without forcing me to waste time and expense in sending them bills. The annual reprint containing our published results for 1948, which appeared in Meteor Notes, should be ready for distribution by March. It will be mailed to all whose dues are paid.

Flower Observatory of the University of Pennsylvania, Upper Darby, Pa., 1949 Jan. 19.

Contributions of The Meteoritical Society

(Known Formerly as The Society for Research on Meteorites)

Edited by FREDERICK C. LEONARD
Department of Astronomy, University of California, Los Angeles 24

A Preliminary Report on the Mineralogy of the Norton County, Kansas-Furnas County, Nebraska, Achondrite (1000,400)

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ABSTRACT

This paper presents a preliminary report on the friable enstatite achondrite, with nickel-iron inclusions, more than a ton of which fell in Norton County, Kansas, and Furnas County, Nebraska, on 1948 February 18 (C.N. = 1000,400). Megascopically, the achondrite resembles a rhyolite porphyry, the fine-grained groundmass of grayish-white color containing phenocrysts of 2 types, the first, a light-gray mineral exhibiting cleavage at angles of 88° and 92°, the second, a clear, glassy mineral which does not cleave or part, but rather shatters with a conchoidal fracture. Under closer examination, both the groundmass and the phenocrysts of the stone are found to consist chiefly or solely of a very pure enstatite. In addition to inclusions of nickel-iron, the achondrite contains abundant small flakes of graphite, and a brown, platy mineral, identified tentatively as diallage. For both the cleavage enstatite and the glassy enstatite, $\alpha = 1.652$, $\beta = 1.654$, $\gamma = 1.660$; and, furthermore, the other optical constants are the same, except that the axial angle found for the glassy enstatite (80° to 85°) is more than twice that found for the cleavage enstatite (40°). Primary, secondary, and tertiary fusion crusts, ranging in thickness from at least 17.7 mm. down to less than 0.2 mm., have been found on the achondrite. Those portions of the fusion rind so far examined microscopically in oil immersions were found to be extremely fine-crystalline, and not glassy, and they had an average index of refraction of 1.656.

1. *Introduction.*—The first recoveries from the Norton County, Kansas-Furnas County, Nebraska, achondritic shower (C.N. = 1000,400), whose occurrence, on 1948 February 18, startled thousands of persons in several midwestern States, were announced, and the meteorite was briefly described, in a note by La Paz, published in May, 1948.[1] In this note, attention was called to the many points of similarity between the February 18 meteorite and the remarkable Cumberland Falls, Whitley County, Kentucky, whitleyite (or "cumberlandite"; C.N. = 844,368), which fell at noon on 1919 April 9.[2] The conclusion, tentatively advanced, that these two meteorites are very similar (a conclusion based in part on gross resemblances between the two stones and in part on determinations made by La Paz of the specific gravities (3.06 to 6.11) of various components of the achondrite; and of the *average* refractive index (1.659), and the length-slow and parallel-extinction characteristics of the mineral of which the meteorite is principally composed) has been borne out by the more detailed megascopic and optical investigations reported on in the second section of the present paper.

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This more detailed study gives support also to a statement made in the note in *Science*[1] to the effect that the February 18 meteorite "possesses certain features so distinctive that it seems quite possible that it will serve as the type stone of a new class of achondrites"; *e.g.,* in addition to the earlier-observed absence from the Norton-Furnas stone of such sporadic inclosures of metal-bearing, black, chondritic stone as Merrill found in Cumberland Falls, and the presence in the February 18 meteorite of nickel-iron inclusions, far larger than any found in the whitleyite (or, for that matter, hitherto reported in any enstatite achondrite), the investigations detailed in the next section have shown that the enstatite of the Norton-Furnas fall is of quite exceptional purity, the observed values of the axial angle, the indices of refraction, and the birefringence corresponding to the presence in the silicate of a very small percentage of iron; that phenocrysts of a clear, glassy enstatite, which neither cleaves nor parts, but rather *shatters* with a conchoidal fracture, are composed of material under considerable internal strain; and that the axial angle for this glassy enstatite is more than double that of the unstrained cleavage enstatite, a difference which we shall give reasons for supposing is somehow dependent upon the strain to which the glassy enstatite is subject. Not any of the peculiarities just cited were noted by Merrill in his exhaustive study of the Cumberland Falls achondrite. Now as Merrill clearly pointed out, at the end of the study just referred to, the differences between the whitleyite and all other achondrites were such as to necessitate the introduction of a new subclass for the Kentucky stone. Consequently, since the Norton-Furnas achondrite, while closely resembling the whitleyite in many important respects, nevertheless, in turn, shows such significant differences from it as those just mentioned, it now seems probable that the February 18 fall will, indeed, serve as the type stone of a new achondritic subclass, *viz.,* a *second* link in the chain connecting the aubrites (Au) and the enstatite chondrites (Cen), of which the first link is the cumberlandite (Cu), as shown in the very useful classificational sequence of meteorites recently published by Frederick C. Leonard.[3] In that chain, the February 18 achondrite would occupy a position *between* the aubrites (Au) and the cumberlandite (Cu).

In addition to its probably unique nature, its world-record-breaking size, to which Frederick C. Leonard has called attention in an interesting paper recently published in these CONTRIBUTIONS,[4] its distinction as the first freshly-fallen meteorite to be exhaustively tested for radioactivities induced by cosmic radiation, or to be studied either by radio-chemical methods after irradiation in the neutron pile or by the nuclear-emulsion plate-technique, the Norton-Furnas achondrite possesses, from the cosmogonic point of view, an importance for the meteoriticist at least as great as that which the conservative Merrill unqualifiedly assigned to the whitleyite. To see this fact, we have to recall only that strong evidence in support of the currently favored "meteorite-planet" hypothesis is furnished by the discovery of meteorites showing unmistakable evidence of their having been subjected to such dynamic metamorphism as must have occurred deep in the lithospheric zone of the supposed planet, in case it actually existed and had a size conforming with that predicted by the fundamental theory of planet structure recently developed by Harrison Brown of the Institute for Nuclear Studies of the University of Chicago.[5] Now to an even greater extent than the celebrated whitleyite, which Merrill regarded as supplying "direct evidence of the destruction of some pre-existing planet,"[6] the Norton-Furnas meteorite shows in its slickensided surfaces, its abnormal development of the cleavage, its highly-strained, glassy, enstatite phenocrysts, and in certain other peculiarities, convincing evi-

dence of having undergone such metamorphic action as accompanies the crustal movements incidental to mountain-making on a planetary scale.

2. *Mineralogy.*—In the present preliminary report, the mineralogy of the Norton County, Kansas-Furnas County, Nebraska, meteorite has been determined megascopically and optically, the latter by the use of immersion media.

A megascopic examination of the meteorite suggests a rhyolite porphyry. The groundmass is of a grayish-white color, fine-grained in texture. The phenocrysts are enstatite of 2 different types. One type is a light-gray enstatite exhibiting the usual pyroxenic cleavage, at angles of 88° and 92°; this resembles a weathered feldspar in a porphyry. The other type is a clear, glassy enstatite; this resembles quartz in a porphyry. The cleavage enstatite reaches a length of 25 mm., and the glassy enstatite occurs in broken fragments of equal length. A closer examination reveals abundant small flakes of graphite, and a brown, platy mineral which has been identified tentatively as diallage, a variety of diopside with a good parting, parallel to {100}. The outside of the meteorite has a fusion rind ranging in thickness from less than 0.2 mm. to at least 17.7 mm.

The following optical constants were obtained for the cleavage type of enstatite: $\alpha = 1.652$, $\beta = 1.654$, $\gamma = 1.660$; optical character, positive; axial angle = 40°; dispersion, $r < v$, weak; optical orientation, $X = a$, $Y = b$, $Z = c$; the axial plane is {010}, cleavage is {110}, at 88° and 92°; parting is {010}, and is unusually well-developed, as judged from the number of centered, biaxial flash-figures and from the ease with which they can be obtained; the cleavage traces are length-slow; and extinction is parallel. Physically, the cleavage enstatite has a hardness of 5.5, and a specific gravity of 3.18 (Jolly balance). The aforementioned constants check very closely with those for pure artificial enstatite.[7] In enstatite, the axial angle, indices of refraction, and birefringence increase rapidly with an increase in the FeO content; so it can be predicted that a chemical analysis will reveal only a small percentage of iron.

The glassy enstatite gives the same constants as those for the cleavage enstatite, with 2 exceptions. This glassy enstatite does not cleave or part; rather, it shatters with a conchoidal fracture. Under the microscope, this glassy enstatite is seen to be under considerable internal strain. The other, and more surprising, difference is that the axial angle for the glassy enstatite is 80° to 85°. Ordinarily, this axial angle would reflect an enstatite with 9% of $FeSiO_3$, but this mineralogical composition would result in higher indices of refraction (namely, $\alpha = 1.665$, $\beta = 1.669$, $\gamma = 1.674$; *v.* ref. ([7]), p. 122) than those actually observed in the case of the material under discussion. Consequently, inasmuch as the glassy enstatite differs physically from the cleavage enstatite only in being under strain, we have concluded that the difference in the axial angles is a function of the strain; this, too, differs from that of terrestrial minerals, in which the strain is reflected usually in a distorted, abnormal interference-figure.

The microscopic observation of the fusion rind in an oil immersion shows it to be extremely fine-crystalline, not glassy, and to have an average index of refraction of 1.656.

At the present time, spectrographic and chemical analyses and thin sections are being prepared. A complete mineralogical report will be made as soon as the thin sections and the analyses have been studied.

REFERENCES

[1] La Paz, Lincoln, "The Norton County, Kansas, Meteorite," *Science*, **107**, 543, 1948; reprinted in *C.M.S.*, **4**, 137; *P. A.*, **56**, 391, 1948.

[2] Merrill, G. P., "The Cumberland Falls, Whitley County, Kentucky, Meteorite," *Proc. U. S. National Mus.*, **57**, 97-105, 1921.

[3] Leonard, Frederick C., "A Classificational Sequence of Meteorites," *C.M.S.*, **4**, 87-92; *P. A.*, **56**, 41-6, 1948.

[4] Leonard, Frederick C., "The Furnas County Stone of the Norton County, Kansas-Furnas County, Nebraska, Achondritic Fall (1000,400)," *C. M. S.*, **4**, 138-41; *P. A.*, **56**, 434-7, 1948.

[5] Brown, Harrison, "The Composition of Meteoritic Matter: III. Phase Equilibria, Genetic Relationships, and Planet Structure," *Jour. Geol.*, **56**, 85-111, 1948.

[6] *V.* ref. (2), p. 104.

[7] Larsen, E. S., & Berman, Harry, "The Microscopic Determination of the Non-Opaque Minerals," *U. S. G. S. Bull. 848* (2nd Ed.), 118, 1934.

The Reported Crater-Producing Meteoritic Fall of 1947 February 12 in Eastern Siberia

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ABSTRACT

In recent issues of these CONTRIBUTIONS, certain Russian news releases concerning the fall of crater-producing meteorites in the Ussuri Taiga in eastern Siberia, on 1947 February 12, are quoted or abstracted. It is the purpose of this paper to record other Russian news items concerning this fall, and to point out the existence of internal inconsistencies in all such news reports; also surprising discrepancies, on the one hand, between them and the information on the Ussuri fall published by Russian meteoriticists, and, on the other hand, between them and the numerous concordant reports relating to the great Podkamennaya Tunguska, Siberia (∓1019,609), fall of 1908 June 30. A summary of the information on the Ussuri fall given in recent important papers by E. L. Krinov is presented, and attention is called to a program for the translation of Russian papers, such as Krinov's, on meteoritics, initiated in 1934-35 at the Ohio State University, by Dr. A. G. Wiens and the writer, and now resumed at the Institute of Meteoritics of the University of New Mexico by the writer, in coöperation with Dr. Alexander W. Boldyreff.

The crater-producing meteoritic fall, reported to have occurred in the Ussuri Taiga in eastern Siberia, on 1947 February 12, has aroused much interest among meteoriticists everywhere. A summary of information on the fall, based on Russian news releases and notes in scientific journals available up to 1947 May, was given by me in San Diego, California, at the time of the A.A.A.S. meeting and the 10th Meeting of the Meteoritical Society there in 1947 June. In this summary, attention was called to internal inconsistencies in Russian news reports of the fall, and to a number of striking differences between the phenomena reported from the Ussuri fall and those widely observed when the crater-producing Podkamennaya Tunguska, Siberia (∓1019,609), meteorite of 1908 June 30 fell. The differences noted between the two falls have not been lessened by more recent news releases concerning the Ussuri incident, nor have the internal inconsistencies in these releases been removed. Two such news items were quoted by John H. Schilling in a recent issue of these CONTRIBUTIONS.[1] These quoted items should be compared, on the one hand, with the *Time* story of 1947 May 5 (p. 74), and *The Griffith Observer*, **11**, 101-2, article of 1947 August; and, on the other hand, with the following accounts, the last of which is quoted from

the 1948 June 2 issue of the newspaper *TRUD*, in a letter written me by Dr. H. E. Landsberg, a Research Associate of the Institute of Meteoritics, on 1948 July 30:

"PLANET BLOW SUSPECTED

"*Moscow, 1947 April 28 (AP).*—Professor V. G. Fesenkov, Chairman of the Meteorite Committee of the Academy of Sciences, said today it was possible that a minor planet collided with the Earth on February 12, 1947, when a missile, described as a meteorite, fell in eastern Siberia.

"'It is now becoming increasingly clear,' Professor Fesenkov said, 'that it was an exceptional phenomenon in many respects. For one thing, some of the fragments smashed thru the surface strata of soil and penetrated into bedrock, leaving several dozen craters, the biggest of them about 75 feet in diameter.'

"He said that it was 'quite possible that what happened in the Far East was the collision of a minor planet with the Earth.'"

"FOREST VANISHES WITHOUT TRACE IN METEOR BLAST

"*London, 1947 July 12 (TASS).*—A forest of 100-year-old cedars vanished without a trace in the explosion of the Sikhote-Alin meteorite, which fell in the Siberian coastal mountains northeast of Vladivostok early this year, *TASS* reported tonight from Alma Ata, Kazakh Soviet Republic.

"Reporting preliminary findings of an expedition from the Kazakh Academy of Sciences, which traveled across Siberia and back, to investigate the phenomenon, the Soviet news agency said:

"'The expedition came to the conclusion that the main meteorite in its fall created an air cushion and broke up on hitting it—before reaching the Earth at all.'

"The scientists found 106 craters and holes in an area 1.2 kilometers by 600 meters (about ¾ths of a mile by 650 yards), and 250 meteorites weighing 5 tons in all, ranging in size from 100 kilograms to 150 milligrams (331 pounds to ⅔ grain), scattered in what they called a 'rain of iron,' after the blast.

"The main crater was 29 meters (95 feet) in diameter and 6 to 7 meters (6½ to 7⅔ yards) deep, *TASS* said.

"'Near the main crater, the dense forest had disappeared without a trace,' the agency said. 'Around the small craters individual trees remained standing, but [were] shot thru with fragments.'"

"IRON RAIN

"*Moscow, 1948 June 2 (TRUD).*—A report has just been received in the Academy of Sciences of the U.S.S.R. that an expedition from the Committee on Meteorites has arrived in the Ussuriiskaya Taiga, on the western spurs of the Sikhote-Alin Mountains. On February 12th, 1947, an iron-meteorite rain fell over a territory of 10 square kilometers in this locality. The Scientific Secretary of the Committee on Meteorites of the Academy of Sciences of the U.S.S.R., E. L. Krinov, told a *TRUD* correspondent:

"'Meteorite bodies move around the Sun in great numbers. The path of one of these crossed the orbit of the Earth. With great cosmic speed (20 kilometers a second) the heavenly body burst into the Earth's atmosphere. Because of the strong pressure of the atmosphere, it became incandescent, and, at an altitude of approximately 10 kilometers, broke into several thousand fragments.'

"'The fall of the fiery body, oblong in shape, with a multi-colored tail, was

observed by residents of villages in a radius of more than 100 kilometers. The meteorite passed thru the sky from north to south, and disappeared after 6 seconds. A few minutes after its disappearance, deafening thuds were heard. These thuds were audible at a distance of 200 kilometers from the place of fall.'

" 'The Committee on Meteorites last year organized a special scientific expedition under the leadership of Academician V. G. Fesenkov to study the circumstances of the fall of the iron rain and to collect meteorites and fragments. The expedition gathered much interesting material, including 257 meteorites weighing from 18/100ths of a gram to 300 kilograms. The scientists discovered 106 craters, which had been formed from the fall of parts of the meteorite body.'

" 'Thousands of meteorite fragments were collected in and around the craters. However, the expedition did not determine conclusively whether the meteorites, which had formed craters averaging about 10 meters in diameter, were preserved whole.'

" 'Therefore, a new scientific expedition, under the leadership of the expert on magnetism, S. S. Fonton, has been sent to the western spurs of the Sikhote-Alin Mountains this spring.' "

The various internally inconsistent news releases issued by the Russians, of which typical samples have just been quoted, differ markedly from the consistent accounts that have been given of phenomena observed at the time of the great Podkamennaya Tunguska fall of 1908 June 30, the only fall of historic times comparable in magnitude to that in the Ussuri region; *e.g.*, there is no mention of an "impact flare," of seismic vibrations, of "air waves" of global extent, of nocturnal atmospheric glows, and of similar occurrences. Furthermore, a critical comparison between Russian news releases, such as those quoted in this article, and Russian scientific reports on the Ussuri fall will disclose not only astonishing gaps in the news items but also the existence of surprising discrepancies between the popular and the scientific versions of the fall. In order that the reader may carry out such a critical comparison, we shall give here a brief summary of the circumstances of the Ussuri fall and the characteristics of the meteorites recovered therefrom as reported in interesting and important papers recently published by E. L. Krinov.

According to Krinov, at about 10:35 o'clock on the morning of 1947 February 12, a heavy shower, *not* of *aerolites*, but of *siderites* or *metallic meteorites* (described by Krinov as an entirely unique iron rain of witnessed fall), took place in the Maritime Province, at a point which is located in latitude 49° 10′ N. and in longitude 104° 19′ *east of Pulkova* [and of which the C.N. = ∓1346,492]. The strewn field of this fall, the boundaries of which are as yet only partially determined, but which is thought to be an ellipse with an area of 7 to 8 square km., having a major axis about 5 km. long, directed *from* azimuth 344° (measured clockwise from the north), is described by Krinov as being sharply divided into 2 subregions, "the head" and "the tail," of quite dissimilar characteristics as regards their area and the nature, size, and distribution of the meteorites and penetration-funnels found within them. (This singular fact is not even mentioned in any of the news dispatches, which fail to specify also that the 106 craters so frequently publicized were all found in the "head area.")

The 106 funnels found in "the head," which, according to Krinov, had diameters ranging from 0.6 meter to 28 meters, and were distributed at random, possessed *structural features* distinguishing them sharply from other known meteorite craters: furthermore, complete individual meteorites (one of which had

shattered into 4 matching fragments), weighing from 68.7 kg. to approximately 300 kg., were found actually buried *within* the several small-to-medium-sized funnels excavated by the scientists of the U.S.S.R. (These extraordinary facts are not brought out by the Russian news stories.)

Finally, both the descriptions and the photographs of the meteorites recovered from the Ussuri fall given in Krinov's papers serve only to emphasize the quite unique nature of these objects in contradistinction to the uninformative or actually misleading accounts given by the Russian newspapers. Krinov refers to the Ussuri meteorites as *octahedrites* (cl. = O), of the same type as that of the Sandia Mountains, New Mexico (1067,350:), iron; and the percentage-composition indicated, *viz.*, Fe = 94%, Ni = 5.5%, Co = 0.38%, does not differ significantly from that obtained by analysis of the Sandia Mountains meteorite, *viz.*, Fe = 92.46%, Ni = 5.92%, Co = 0.53%; however, as Stuart H. Perry has pointed out, Sandia Mountains is a *granular hexahedrite* (cl. = H,a); and some, but not all, of the singular features of the Ussuri irons can at once be explained by assigning them to that class. Perhaps the very unusual nature of the Russian irons can best be brought out by noting that the specimen figured by Krinov as representative of the complete individuals recovered, in addition to exhibiting the normal (if always curious) macrograins and other features of the conventional granular hexahedrite, displays a kamacitic toadstool-like appendage consisting of a projecting spire of metal surmounted by an irregular tabular roof of the same material (*v.* Fig. 1). Other specimens closely resemble pieces of armor-plate

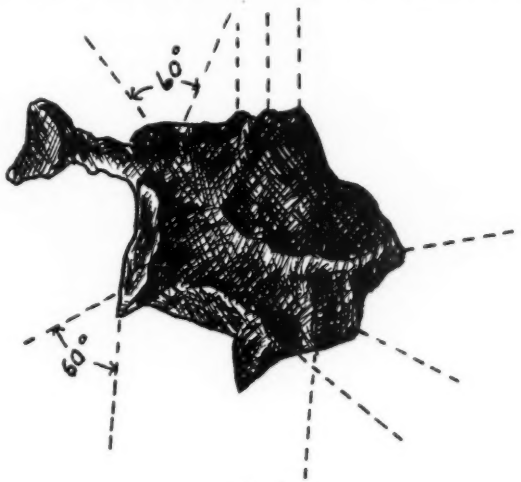

FIG. 1
A COMPLETE INDIVIDUAL OF THE USSURI FALL AS FIGURED BY KRINOV

shattered by the impact of projectiles or by charges of high explosives. Krinov refers to *S*-shaped specimens with torn, sharp ends, often exhibiting thin, long, and bent projections. He notes also that the convex surfaces of some of these Ussuri specimens show intensely blue and even rainbow-like colorations.

Whatever the final appraisal of the Ussuri incident, enough has been cited

from Krinov's work to show that in 1947, as in 1908, an event of the utmost interest to all meteoriticists occurred in Siberia, and that, except for the demonstrably incomplete and inaccurate accounts published in English by the Russian news agencies, all information concerning this event seems doomed to be hidden away in the intricacies of the difficult and unfamiliar Russian language.

In recognition not alone of the then-unique character of the Podkamennaya Tunguska fall of 1908 June 30, but also of the very important work being done by Russian meteoriticists, Dr. A. G. Wiens and I, at the Ohio State University, in 1934-35, embarked on a program for the translation of papers concerning the Podkamennaya Tunguska fall, written by L. A. Kulik and I. S. Astapowitsch. Since the publication of our translations and critical commentaries,[2] work of increasing importance in meteoritics has been done by the Russians, and, in addition, such phenomenal incidents as the one to which the present paper is devoted have occurred within the U.S.S.R.; therefore, in collaboration with Dr. Alexander W. Boldyreff, of the Department of Mathematics and Astronomy of the University of New Mexico, I have reinstituted the program earlier initiated with Dr. Wiens. At present, our interest centers naturally on the numerous articles concerning the Ussuri fall, published by the Russian meteoriticists; among these may be mentioned the important series of articles by Fesenkov,[3] and papers by Shipulin,[4] Krinov,[5,6] and Divari.[7] However, we hope to be able later to give attention to the many papers of *general* meteoritical interest appearing in such Russian journals as *Meteoritica*. Because now, just as ten years ago, the task of promptly securing copies of Russian scientific publications is one of our most difficult problems, an appeal is hereby issued for the donation or loan of such publications, which may now be in, or may later come into, the possession of members of The Meteoritical Society.

References

[1] John H. Schilling, *C.M.S.*, **4**, 135-7; *P.A.*, **56**, 389-90, 1948.

[2] Lincoln La Paz & A. G. Wiens, *C.S.R.M.*, **1**, No. 1, 29-34, 35-9, 1935; **1**, No. 2, 15-20, 1936; **1**, No. 3, 29-33, 1937; **2**, 203-26, 1940; and *P.A.*, **43**, 499-504, 596-9, 1935; **44**, 215-20, 1936; **45**, 328-32, 1937; **48**, 433-43, 493-506, 1940.

[3] V. G. Fesenkov, "The Gigantic Meteorite of 12 February, 1947," *Nauka i Zhizn*, No. 11, 1947; *Astronomical Journal* (U.S.S.R.), **24**, No. 5, 302, and No. 6, 302, 1947.

[4] F. K. Shipulin, *Prioda*, No. 5, 50, 1947.

[5] E. L. Krinov, *Uspekhi Astron. Nauk* ("Successes of the Astronomical Sciences"), **3**, 257-8, 1947.

[6] E. L. Krinov, "Some Characteristics of the Sikhote-Alinsk Iron-Meteorite Shower," *Reports of the Academy of Sciences, U.S.S.R.*, New Series, **59**, No. 3, 459-62, 21 Jan., 1948.

[7] N. B. Divari, "Determination of the Trajectory of Movement of the Sikhote-Alinskiy Meteorite on the Basis of the Testimony of Witnesses," *Astronomical Journal* (U.S.S.R.), **25**, No. 1, 66-73, Jan.-Feb., 1948.

The Mineralogy and Origin of Josephinite*

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ABSTRACT

Josephinite is a naturally-occurring, terrestrial nickel-iron alloy, found along Josephine Creek, Josephine County, Oregon, and associated with stream gravels as water-worn pebbles, sometimes ellipsoidal in shape. A group of more than 75 specimens examined gave the following physical and chemical data: average sp. gr., 5.66; hardness, 4.5 to 5.0; streak, lead-gray; luster, metallic; fracture, hackly; malleable, sectile; strongly magnetic; opaque. The group of specimens examined ran as follows: largest dimension, 3.2 mm. to 31.4 mm. The chemical formula for josephinite is written usually as Fe_2Ni_3, altho josephinite contains also a little cobalt, phosphorus, and sulfur.

Josephinite is a naturally-occurring, terrestrial nickel-iron alloy, found associated with stream gravels along Josephine Creek, Josephine County, Oregon. It was first reported by W. H. Melville in *The American Journal of Science*, **43**, 509, 1892. Josephinite is formed probably by the magmatic separation from peridotite magmas; these are later altered by hydration to form serpentine. Josephinite is found associated with chromite, magnetite, gold, silver, and platinum, in stream gravels; because of its high specific gravity, it tends to collect at bedrock, together with the aforementioned minerals, where it may be recovered by sluicing. For many years mineralogists have assumed that josephinite was derived from the serpentine thru which Josephine Creek has cut its channel; actual samples have never previously been described, however, in which josephinite was found adhering to its serpentine matrix. From this lack of evidence, the idea that josephinite might be of meteoritic origin was obtained. Some investigators have thought that perhaps blebs of molten metal, showered from a large meteorite, might have been responsible for its occurrence; others have reasoned that part of a large meteorite, perhaps the missing Port Orford, Curry County, Oregon (C.N. = 1245,428), pallasite disintegrated, covering the area with thousands of small metallic fragments, later to be washed down and to be deposited in the Josephine gravels.

In the summer of 1948, I proposed to Dr. J. Hugh Pruett, astronomer of the University of Oregon, that I should make a study of josephinite and attempt to prove definitely whether it is of terrestrial origin. With the kind coöperation of a number of miners in the Kerby area, I was able to secure about 75 specimens of this mineral; in addition to studying these specimens, I made an extensive investigation of the Josephine Creek area, paying particular attention to the stream gravels. In the course of this work, I brought to light several fine specimens of josephinite with serpentine matrix adhering.

The accompanying data (in Table 1) resulted from a laboratory examination of this material. From these data it will be noted that my observations warrant the suggestion that a change should be made in the reported specific gravity and hardness of josephinite. The present reported specific gravity is 6.20, and the

*[Altho this paper is, strictly speaking, on a mineralogical rather than a meteoritical subject, it is here included because of the similarity in chemical composition between josephinite and nickel-rich ataxites (cl. = D_1), and because josephinite itself has occasionally been suspected of being meteoritic in nature.—F.C.L.]

hardness, 5.0. A careful check of the specific gravity of the 15 specimens listed in Table 1 yields an average specific gravity of 5.66. The specific gravity ranges from 4.43 to 6.94. The lower specific gravities are due probably to oxidation products. The hardness ranges from 4.5 to 5.0.

TABLE 1. PHYSICAL PROPERTIES OF JOSEPHINITE

Specimen No.	Specific Gravity	Specimen No.	Specific Gravity
1	5.92	9	5.96
2	4.43	10	5.32
3	4.78	11	5.43
4	5.17	12	5.01
5	5.53	13	6.53
6	6.80	14	6.94
7	5.66	15	5.43
8	6.91		

Average sp. gr. of specimens 1 to 15 inclusive: 5.66; lowest sp. gr. observed: 4.43; highest sp. gr. observed: 6.94. Streak, lead-gray; luster, metallic; fracture, hackly; malleable, sectile; strongly magnetic; hardness, 4.5-5.0.

Josephinite is found occurring in stream gravels as water-worn pebbles, some of which are ellipsoidal in shape. A group of more than 75 specimens examined ran as follows: largest dimension, 3.2 mm. to 31.4 mm. The mineral has been reported as occurring more rarely in the form of much larger specimens.

TABLE 2. CHEMICAL PROPERTIES OF JOSEPHINITE

(The chemical formula is written usually as Fe_2Ni_5 or $FeNi_3$.)

$FeNi_3$: % of $\begin{cases} Fe = 27.57 \\ Ni = 72.43 \end{cases}$

Fe_2Ni_5: % of $\begin{cases} Fe = 24.08 \\ Ni = 75.92 \end{cases}$

ANALYSIS†

Fe	25.24%
Ni	74.17
Co	0.46
Cu	Nil
P	0.04
S	0.09
SiO_2	Nil
Total	100%

Josephinite is soluble in HNO_3; it gives a scarlet precipitate with dimethylglyoxime reagent after the removal of the iron by precipitation with NH_4OH.

†From E. S. Dana's *System of Mineralogy*, 7th Ed., **1**, 117, 1944.

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Secretary of the Society: OSCAR E. MONNIG, 1010 Morningside Drive, Fort Worth 3, Texas

Meteor Research from Movable Base

We are accustomed to associate scientific research of all kinds with fixed and permanent installations. Recently, however, we have learned of an elaborate experiment which involves a mobile laboratory and observa-

tory. Our information comes from a news release from Harvard University. Because of its importance and intrinsic interest, we are printing the release in its entirety. EDITOR.

Associate Professor Fred L. Whipple of the Harvard College Observatory recently described the establishment and successful operation of the first mobile photographic observatories to be used for research on the behavior of meteors. Now making nightly photographic records of meteors from a station in southern New Mexico, these "observatories-on-wheels" were designed especially for use in the new Harvard Photographic Meteor Program. This program, which is sponsored by the Bureau of Ordnance of the U. S. Navy, was described by Professor Whipple to a meeting of the American Astronomical Society in New Haven, Connecticut, on December 30. Primary purpose of the meteor program is to provide not only precision astronomical data on the nature of the meteors and their orbits, but also information on upper atmospheric densities and temperatures, and seasonal variations in the densities. A further purpose is to use the thin air found at heights of 50 to 100 miles above the earth as a proving ground for rocket and other high-velocity ballistic research. Results of the meteor research are being correlated with V-2 rocket studies.

After only several months of observing, some theories on the behavior of meteors have been confirmed and others found inaccurate. For instance, study of meteor photographs already taken has shown that the density of the atmosphere around the earth follows the average ground temperature. This confirmed that solar insulation, local temperature variations, or the activity of storm fronts are not responsible for variations in density as previously thought. The work is also expected to provide new data on the nature and role of the ionosphere—the upper layer of the earth's atmosphere which figures in radio communications, weather variations, and the climate of the world. More data on winds in the high atmosphere are also being accumulated.

Photography began at this site last August, a month after the caravan of six vehicles—known locally as "Whipple's Wagon Train"—left the grounds of the Harvard College Observatory in Cambridge. Mounted on surplus government trucks and trailers, the observatories roll under their own power and can be moved anywhere a wheeled vehicle can go.

This particular area, 40 miles north of the Mexican border and near the city of Las Cruces, New Mexico, was selected to be the first observing station because it has a near-maximum amount of clear sky available anywhere in the United States. Six hours of clear sky per night on the average is found in this area. Although meteor photographing can be done only in "dark-of-the-moon" nights, in the last five months hundreds of photographic plates have been exposed.

Photographs are made simultaneously at two stations, the Soledad station, 12 miles east of Las Cruces, and the Dona Ana station, 12 miles north of Las Cruces. Separate stations and the two-camera method make it possible to measure the height of meteor trails within a few feet and chart their path more accurately. By this method scientists are securing data from which the density of the atmosphere can be determined at heights of from 30 to 75 miles. Communication between the stations is maintained by radio telephone which is used mainly for synchronizing exposures.

The assembling and most of the construction of the new type observatories was done by two young veterans, Mr. Harlan J. Smith of Wheeling, West Virginia, and Mr. Richard E. McCrosky of Boston. Both are in their early twen-

ties. Smith has returned to Harvard and McCrosky is still with the expedition and on leave from the College. They were assisted on the photographic end of the project by Mr. Phillip Carroll, Jr., of Lovell, Maine. McCrosky and Carroll are at present operating the observatories. Equipment at each station consists of a camera, trailer, a power plant in truck or trailer, a mobile laboratory with plexiglass observing dome and darkroom. Resting on a heavy concrete pier to reduce vibration, the trailer is constructed so that the entire body will roll away on a trestle to open the cameras to the sky. Through the plexiglass dome the observers make the visual observations to provide the instants of the meteors photographed and those recorded by radar.

Of the three pairs of cameras now in use, two are old patrol cameras and one was put together from surplus aerial camera lenses K-24. These small photographic cameras are equipped with rotating shutters and synchronized so that meteors are photographed simultaneously at the two stations. These cameras will be replaced within the next year with two Super-Schmidt meteor cameras now under construction. Designed by Dr. James G. Baker, a former Junior Fellow at Harvard, the fast wide-angle lenses of these cameras are expected to extend the magnitude range of photographic meteors approximately four magnitudes below the limits now set with conventional lenses. With them Dr. Whipple explained it will be possible to take in as broad a sweep with the camera as with the best small cameras. The new camera will increase the meteor "yield" by a factor of some 40 times, he says.

The reduction of the observational data procured is being carried out by the Massachusetts Institute of Technology Centre of Analysis under the direction of Dr. Z. Kopal and Dr. L. Jacchia.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Publications of the Lyons Observatory: Among numerous publications of the Lyons Observatory recently received at headquarters are several which deal with variable stars. The second part of Volume VII of the *Bulletin of the French Variable Star Association* contains the original observations of long-period and irregular variables made during the prewar years 1937-38 by the members of that association. Many of these observations at faint stages supply valuable data which were missing in our own records. Volume IV of the regular publications of the Lyons Observatory also contains discussions of the Cepheid variable RT Aurigae, in photographic and visual light; the eclipsing variable VV Orionis; and photometric observations of the Cepheid variable FF Aquilae.

Current Notes on the Variables: T Cas, 001755, presents a still-stand on the rise to maximum near JD 2432900.

R And, 001838, at or near maximum.

S Ari, 015912, the first maximum observed in the past two years, period 294 days.

UV Per, 020356, seldom found brighter than magnitude 13. Last maximum observed near JD 2432775, magnitude 12.5.

Omicron Cet, 021403, well observed maximum at JD 2432824, magnitude 3.6.

R Hor, 025050, well on way to a bright maximum.

SU Tau, 054319, still at maximum brightness, about magnitude 9.5.

SS Aur, 060547, at maximum JD 2432823 and 2911.

Nova (RR) Pic, 063462, slowly fading, now at magnitude 9.9.

U Gem, 074922, at maximum, JD 2432854.

Nova Pup, 080835, slowly fading, now at magnitude 9.9.

Z Cam, 081473, for the past 300 days has shown only slight variation, around magnitude 11.5, evidently a period of comparative quiescence in contrast to its usual two magnitude amplitude.

Z UMa, 115158, slightly fainter than usual, now at magnitude 8.3.

R Com, 115919, due to rise rapidly to maximum.

Delta UMa, 121257, varying irregularly over a small range, 3.4 to 3.9.

T Aps, 134677, apparently went through a protracted still-stand on the way to its maximum of JD 2432748.

S Aps, 145971, still faint, below magnitude 13.0, and subject to irregularities at its present stage.

Nova Ser, 154114, has slowly faded from magnitude 8.5 to near 11.5 in the past seven months.

R CrB, 154428, began to fade late in November and, with some halts on the way down, had reached magnitude 9.0 by the end of December. The star's previous minimum occurred about two years ago, when it decreased in an irregular manner to magnitude 11.5, and occupied about 140 days from maximum through minimum and back to maximum.

T CrB, 155526, is back to its pre-outburst stage at 10th magnitude, with little change in brightness over the past twenty months.

Alpha Her, 171014, appears to have varied from magnitude 3.0 in July to magnitude 3.6 at the present time.

Nova (RS) Oph, 174406, is now near a minimum, magnitude 12.0, having steadily decreased during the past year from magnitude 10.5.

R CrA, 185537a, one of the variables involved in nebulosity, is exceptionally bright at this time, around the 10th magnitude, whereas it was observed near magnitude 13.5 a year ago.

RY Sgr, 191033, is now back to normal maximum brightness, between magnitudes 6.5 and 7.0. At minimum, a year ago, it was observed at magnitude 13.5, and from maximum through minimum and back to maximum nearly two years were spent.

Chi Cygni, 194632, reached maximum, magnitude 4.6, in July, 1948, and is well down towards minimum at this time. There was no indication of a still-stand on the increase to maximum, and the light curve from minimum back to near minimum is exceptionally well observed.

RR Tel, 195656, as late as November 27, was still near magnitude 7.0, with no indication of a marked decrease in brightness.

V Sge, 201520, has been varying irregularly between magnitudes 11 and 12, and since November has further decreased to magnitude 13.0.

UX Cyg, 205030a, with a period of 560 days, is due to begin a rapid increase to maximum.

SS Cyg, 213843, was at maximum, number 368, late in October and again

on December 10. In between, the star varied irregularly between magnitudes 11.0 and 12.0.

Z And, 232848, which varies rather slowly between magnitudes 9.0 and 10.3, is now on the increase to maximum, having passed through a minimum about ten months ago.

R Cas, 235350, increased to an exceptionally bright maximum, magnitude 5.4, late in November.

General note: On examination of the current plots, a marked deficiency in the completeness of certain light curves is noticeable, especially for those stars situated between southern declination 20° and 30°, and in the constellations of Virgo, Libra, Scorpio, and Sagittarius.

Observations received during December: A total of 3,927 observations was received in December from 62 observers, as follows:

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Ahnert	53	578	Kulin	1	2
Ancarani	25	33	Lacchini	34	84
Bajocchi	13	31	Lankford	8	8
Blunck	19	19	Luft	7	33
Bogard	49	116	Miller	17	17
Cain	7	7	Oravec	74	251
Caraioryis	5	5	Paletsakis	8	54
Chandra	86	111	Parker	19	20
Chassapis	123	207	Parks	21	21
Cilley	23	51	Pearcy	58	60
Dafter	7	15	Pe.tier	150	187
Daley	4	8	Penhallow	27	51
Darling	7	8	Pierson	52	74
Darnell	5	9	Plakidis	7	17
Davis, M.	7	7	Rakosi	3	8
Dillon	6	8	Reeves	2	3
Elias	25	61	Renner	118	118
Escalante	83	90	Rosebrugh	19	57
Estremadoyro, V. P.	5	9	Seagroves	7	7
Fernald	308	515	Sill	12	12
Focas	7	7	Svolopoulos	22	30
Garneau	10	10	Taboada	96	100
Gingerich	7	11	Tarbell	12	17
Greenley	50	101	Tifft	8	8
Hamilton	10	14	Tsuneoka	12	20
Hardi	4	10	Venter	15	26
Hartmann	186	200	Waters	3	3
Herring	14	18	Webb	15	16
Hiett	9	10	Werntz	15	29
Howarth	17	20	Yamada	19	43
Kantos	4	9	—		—
Kobos	2	2	62	totals	3,927
de Kock	109	251			

January 10, 1949.

Comet Notes

By G. VAN BIESBROECK

As the year 1949 begins there is a long list of previously found comets under observation, all of them losing in brightness and most of them beyond the power of ordinary telescopes.

In order of increasing right ascension we find in the evening sky: Periodic Comet Neujmin (1948 *f*), Comet Ashbrook-Johnson (1948 *i*), Comet Mrkos (1948 *a*), and Comet Pajdusakova (1948 *d*), all of which are now very faint, the last one being the brightest at about 13th magnitude.

Next comes the southern comet Bester (1948 *m*) which was recorded here the first time on January 3 as a 12th magnitude object at declination —28°. It is moving rapidly northward and will cross the equator on February 3 but will be quite faint by that time.

The periodic comet Oterma (1942 VII) which has been observable throughout its whole orbit should remain in reach of large telescopes for some time, as well as periodic comet Whipple (1947 *g*) which has already been followed for 18 months at this apparition.

Farther east we come upon the receding comet 1948 *l* which was so conspicuous in the southern hemisphere last November. When seen here on January 3 there was little left of the recent brilliancy. The total brightness was estimated as 9th magnitude and the tail was only faintly visible. By the middle of February the brightness will have dropped below 12th magnitude but the position is still favorable in Orion.

In the middle of the night we encounter periodic comet Schwassmann-Wachmann No. 1 (1925 II) which was extremely faint on January 7 and 8 but which should be watched for one of its unpredictable outbursts of light.

In the early morning hours the second periodic comet Schwassmann-Wachmann No. 2 is still well located in Virgo. It has now been observed for 15 months at this return. It comes to opposition early in April and should remain in reach of larger telescopes for several months more. On January 7 I estimated the magnitude as 15.

The last object that should be mentioned on this long list is comet Honda (1948 *n*). It was independently picked up by the Czech observers, Mrkos and Pajdusakova, two days after the discovery in Japan. On January 8 I could not find it near the predicted location. A somewhat better exposure the next morning revealed only a 17th magnitude hazy spot that might be the comet but this requires confirmation. There has evidently been an unexpected loss in brightness which will prematurely end the measures.

Both L. E. Cunningham and A. Schmidt have noticed some analogy of the preliminary orbit with that of periodic comet Biela, the well-known object that broke up in two parts in the first half of last century. It is to be hoped that southern observers will have better luck in following that faint object.

Williams Bay, Wisconsin, 1949 January 11.

General Notes

The Rittenhouse Astronomical Society, of Philadelphia, held its regular monthly meeting on January 14, 1949, in Randal Morgan Physics Laboratory, University of Pennsylvania. New officers were installed, and the retiring President, Mr. Edwin F. Bailey, spoke on the topic, "Reflections on Refractors."

Sir Harold and Lady Spencer Jones will arrive in New York on February 7 for a three-month visit to the United States. The Astronomer Royal will first lecture at a few universities in the East, then will go south and will visit McDonald Observatory for two days. He will then be the guest of the Mount Wilson and Palomar Observatories and the California Institute of Technology for a period of three weeks. One week will then be spent at the Lick Observatory and another week at the Berkeley campus of the University of California. A number of lectures will be given in the Wisconsin, Illinois, Michigan, Indiana, and Ohio areas. Back in the East he will lecture before the American Academy of Arts and Sciences and the American Philosophical Society.

Telescope for Agnes Scott College. — Agnes Scott College, Decatur, Georgia, has recently purchased a 30-inch reflector. The Perkin-Elmer Corporation of Glenbrook, Connecticut, is reconditioning this instrument and modifying it to suit the requirements of the latitude of its new location. The College also has plans for a new observatory to house this instrument. This observatory will be the first one of such extensive instrumental equipment in the southern part of the United States.

Northeastern Region of the Astronomical League

At a meeting of the Council of the Northeastern Region of the Astronomical League, held at Harvard College Observatory, plans for the next Regional Convention were discussed by Mr. Rothschild. The meeting will be held in New York at the American Museum of Natural History on Saturday and Sunday, April 23 and 24, which is the weekend following Easter. Sponsors will be the Jr. Astronomy Club of New York, the Paul Revere Boys Club of Jersey City, and the Bergen County Astronomical Society. Plans have been made for a business meeting on Saturday afternoon, followed by a presentation of papers in several discussion sections. On Saturday evening a dinner will be held, followed by trips to several of the nearby observatories. Sunday morning there will be a further session with presentation of papers, with adjournment planned for early afternoon to permit members to return home Sunday evening.

Louisville Astronomical Society

The Louisville Astronomical Society recently celebrated the fifteenth anniversary of its founding (October, 1933) with two events.

On Saturday, November 29, the moving picture in color, loaned by the California Institute of Technology entitled "The Story of Palomar," was presented in the auditorium of Halleck Hall to an assemblage of some seven hundred persons, including all degrees of astronomical interest from the merely curious to the professional. Addresses were made by President K. R. McElwain and Mr. Charles Strull of the Educational Committee.

On Tuesday, December 7, a dinner meeting with an attendance of some forty-seven members, was held with Mr. Strull presiding as Master of Ceremonies at which many of the past presidents gave brief summaries of their terms of office. Among the speakers, who had at various times in the past appeared before the Society, were mentioned, Dr. Sibley, Dr. Robert A. Milliken, Dr. E. J. Yowell, Dr. H. H. Downey, Dr. Van Biesbroeck, Dr. Harlow Shapley, Dr. Bart J. Bok, Mr. Latimer J. Wilson, besides many speakers of local renown. Interspersed was a musical program, and plans for the completion of the Society's

twenty-inch mirror and its mounting and housing were discussed. The Society is looking forward to a greatly increased membership and to pronounced activities in the coming year. B. F. KUBAUGH, *Secretary-Treasurer.*

Summary of Sun-Spot Observations at Mount Holyoke College, 1948

Month	No. of Obs.	North of Equator No. of Groups	North of Equator Av. Lat.	South of Equator No. of Groups	South of Equator Av. Lat.	Av. No. Groups at one Obs.	New Groups
January	19	9	+17°0	21	—13°5	6.9	30
February	18	10	16.8	20	13.2	6.8	29
March	20	19	15.3	26	11.3	7.0	40
April	21	21	18.1	22	14.6	10.7	36
May	16	17	17.8	15	13.7	8.2	26
June	16	23	15.7	22	12.9	8.9	41
July	25	24	13.5	22	11.1	8.9	41
August	24	19	13.1	28	14.8	10.6	40
September	24	20	13.4	31	14.0	8.8	43
October	24	26	12.0	24	14.9	8.6	43
November	18	21	15.5	14	10.9	6.6	31
December	18	17	14.8	18	12.2	7.1	33
Totals	243	226		263			433

Average number of groups at one observation..... 8.37
Average latitude of 200 groups north of the equator.....+14°79
Average latitude of 233 groups south of the equator.....—13°19

This report shows sun-spot activity at a definitely lower level than in 1947, the year of a high maximum. The drop in 1948 is not steady from month to month; peaks of activity in April and August run well above the average activity for 1947. The continued unusual intensity of the present cycle is shown by the fact that the average number of groups (8.37) at one observation (probably the fairest index here given) is for 1948, the year *after* maximum, still well above the value (7.90) for 1937, the year of maximum in the previous cycle.

The latitudes of outbreak are comparable with those of the year following the previous maximum. The dissymetry of the average latitude of spots in the two solar hemispheres persists with the same sign as in recent years, *i.e.*, northern groups average farther from the equator than southern; indeed since 1912 only one fairly active year has shown a marked reversal in this respect.

The maximum count of *spots* (404 in 10 goups) occurred on May 12, of *groups* (15) on July 31 and August 3. On three dates (Jan. 31, Sept. 7, Nov. 30) the number of groups dropped to a minimum (3). Only 5 groups were recorded beyond ±30° in solar latitude, 37 groups within 5° of the equator. 15% of the 433 groups were seen only once; 41% not more than thrice.

Counts and records of position were made during the first five months of the year largely by Miss Ruth Hayner. Occasional assistance from Miss B. Hubbard, Miss E. Jacoby, Miss B. Hanover, and Miss J. Morton is acknowledged. The total number of individual spots counted was 15,530. This indicates a value (64) for the average number of *spots* per observation very slightly less than the corresponding figure (67) for the year 1947. Besides being sent monthly to Washington and quarterly to Zürich, numbers of spots and positions of groups are being utilized in the five-year foreshortening project conducted by Dr. Gleissberg. The data are forwarded to Istanbul through the courtesy of the Solar Division of the AAVSO. ALICE H. FARNSWORTH.

John Payson Williston Observatory, Mount Holyoke College, South Hadley, Mass., January, 1949.

Atomic Clock Developed by National Bureau of Standards*

In a radical departure from all conventional methods of measuring time, an atomic clock—invariant with age and for the first time independent of astronomical observations—has been developed by the National Bureau of Standards. Based on a constant, natural vibration frequency of atoms in the ammonia molecule, the atomic clock is a scientific achievement which offers an entirely new primary standard of frequency and time. The principle of the atomic clock promises to free man from age-old methods of fixing time by the daily rotation of the earth on its axis as it revolves around the sun. Not only does the new clock promise to surpass in accuracy any time measurement heretofore known, but the primary standard, the earth, is very gradually slowing down. In addition, unaccountable fluctuations in the rate of rotation have sporadically lengthened and shortened the day. The new method offers an invariant master clock against which the variation in timekeeping of the earth could be measured.

This first atomic clock has run with a constancy of better than one part in 20 million and is already being improved. By use of the proper atomic system a potential accuracy of a part in ten billion is theoretically indicated.

Based on a principle developed by Dr. Harold Lyons, Chief of the Microwave Standards Section of the Bureau's Central Radio Propagation Laboratory, the new clock was constructed under his direction and with the assistance of B. F. Husten and E. D. Heberling. "Dr. Lyons and his colleagues have made an outstanding contribution to science and technology," according to Dr. E. U. Condon, Director of the National Bureau of Standards. "The precision offered by the new atomic standard is of fundamental importance to astronomy, physics, chemistry, and engineering. The method should prove an invaluable tool for basic research and will affect every technical field where precise measurements of time and frequency are crucial." The principle used in the atomic clock should greatly improve astronomical observation, long-range navigation, and communication systems, precise surveying, military mapmaking, and systems where atoms can serve as electronic components, such as in radio filters, telephone relays, and radar.

The National Bureau of Standards atomic clock consists essentially of a quartz crystal oscillator, a frequency multiplier, a frequency discriminator, and a frequency divider, all housed in two small cabinets on the top of which are mounted a special 50-cycle clock and a waveguide absorption cell—a 30-foot copper tube wound in a compact spiral around the clock and filled with ammonia gas. The crystal oscillator generates a fundamental driving signal at a low radio frequency. A frequency-multiplying chain transforms this into a microwave (very-high-frequency) signal, which is then compared with a natural vibration frequency of the ammonia molecule. If these two frequencies are different, an "error signal" adjusts the oscillator to bring them into agreement. The oscillator which is inclined to "drift" slightly with age—that is, change in frequency—is thus "locked" to the ammonia molecule. It can then control an electrically driven clock with extreme accuracy.

Present time and frequency standards are based on astronomical determination of the period of rotation of the earth. Essentially, a telescope is pointed toward a star, and the interval between the exact moment it passes the crosshairs until the exact moment 24 hours later that the star reappears is taken as

*From a news release by the National Bureau of Standards, U. S. Department of Commerce, Washington 25, D. C.

the standard of time. The "twinkling" of the star, which makes its position difficult to fix, affects the accuracy of such measurements. The atomic clock gives a time standard of high precision continuously available in any interval of time desired instead of every 24 hours, whether it is a millionth of a second or ten hours. Moreover, the atomic clock is invariable so that a given interval of time, whether measured today or a hundred years from now is truly reproducible. The atomic method automatically and continuously controls the rate of the clock without delay or human intervention and is independent of weather.

Astronomers first discovered that the earth's timekeeping was not constant when, in using old computation tables, they found their telescopes were not pointing correctly because of changes in time due to a gradual slowing down in the rate of the earth's rotation as a result of tidal friction in shallow seas. Likewise, fluctuations from unknown causes were observed. In the early 1870's the day was shorter than average by a few thousandths of a second, about 1900 it began getting longer again, and in 1920 once more began to shorten.

Another advantage of the atomic method is that if an atomic clock were run continuously over a period of a year, our knowledge of the length of the year could be improved. The time it takes the earth to travel around the sun (a year) is completely independent of the time it takes the earth to rotate once on its axis (a day). This independence causes all the trouble with the calendar, necessitating leap years so that the seasons will always come at the same time during the year. With an atomic clock measurements could determine whether the mean sideral year is more accurate than the mean solar day, as some astronomers believe may be the case.

In terms of the regular 24-hour-day broadcasts of time and frequency by the National Bureau of Standards, which serve the Nation and much of the world for standards of radio frequencies and time, an atomic clock means a precision of both time and radio-frequency standard signals hitherto impossible. These services are used by the armed forces, by commercial broadcasting stations, by manufacturers of electronic, electrical, and musical equipment, by air and steamship lines, and by universities and research laboratories.

The atomic clock gives the Bureau a time standard analogous to the Bureau's new atomic standard of length furnished by the single isotope of mercury which, if adopted internationally, will provide man with the ultimate standard of length. Both of these recent developments stem from the application of atomic physics to practical problems. The atomic clock is, therefore, another example of the growing importance of atomic physics to daily life.

Provisional Relative Sunspot Numbers

These sunspot numbers were published regularly in *Monthly Weather Review* until the end of 1947. When the publication of them was discontinued in that journal, a request came to POPULAR ASTRONOMY to assume this service for workers using this information. Accordingly we turned to Mr. Neal J. Heines, Director of the AAVSO Solar Division, for assistance in the project. Mr. Heines readily undertook to collect and furnish the data from month to month. At our request also, he has explained in the following paragraphs the source, meaning, and purpose of the tables.

"Provisional Sunspot Numbers are released each month *via* short-wave radio and postal services by Professor M. Waldmeier, Director of the Federal Observatory of Switzerland. This observatory is the headquarters for sunspot statis-

tics, so appointed by the International Astronomical Union. The numbers are dependent only on observations at Zürich Observatory and its stations at Locarno and Arosa, Switzerland.

"Provisional numbers involve observed data and the Wolf formula which is $R = k(10g + f)$. 'They comprise the number of groups of spots on the sun's surface on a given day and also the number of individual spots. Whilst each spot counts as one, each group counts as ten, and hence the relative number is the number of groups, multiplied by ten, plus the number of individual spots. Moreover in order to consider and treat in conjunction with each other the observations made by several observers with instruments of different powers, Wolf reduced them to the same basis by means of properly calculated factors, taking the factor 1 (one) for his observations made at Zürich with a telescope of 10 cm aperture and an enlargement of 64.' (The Sun, Abetti; pp. 68-69.)

"Provisional Sunspot Numbers are preliminary. They differ from the Final Relative Sunspot Numbers in that they are not used for the determination of Sunspot Epochs, but for the establishment of current trends in sunspot activity.

"The Final Relative Sunspot Numbers are obtained by the use of a smoothing process in which the moving averages for every 12 (twelve) consecutive months are taken, and by taking the averages of every 2 (two) twelve months averages. The Final Relative Sunspot Numbers are used also for the correlation studies of various investigations on Solar and Terrestrial phenomena where long series of known data are available.

"Provisional Sunspot Numbers will be published in POPULAR ASTRONOMY each month and the Final Relative Sunspot Numbers as soon as available each year."

Those for November and December, 1948, follow.

November 1948	Relative Numbers	November 1948	Relative Numbers	November 1948	Relative Numbers
1-	85	11-	107	21-	123
2-	100	12-	110	22-	95
3-	85	13-	127	23-	90
4-	88	14-	102	24-	83
5-	88	15-	85	25-	70
6-	88	16-	83	26-	70
7-	70	17-	118	27-	68
8-	69	18-	123	28-	71
9-	79	19-	147	29-	73
10-	84	20-	141	30-	73

November Mean Value 93.2.

December 1948	Relative Numbers	December 1948	Relative Numbers	1948 December	Numbers Relative
1-	64	12-	124	22-	176
2-	70	13-	131	23-	188
3-	100	14-	128	24-	169
4-	110	15-	132	25-	211
5-	85	16-	177	26-	172
6-	85	17-	192	27-	152
7-	85	18-	213	28-	138
8-	92	19-	221	29-	140
9-	102	20-	210	30-	144
10-	96	21-	200	31-	135
11-	92				

December Mean Value 139.8.

Book Review

The Computation of Orbits, by Paul Herget, Director of the Cincinnati Observatory, Cincinnati 8, Ohio. (Published privately by the author.)

The rapid development of high-speed computing machines during the past two decades has changed considerably the outlook of the computer of orbits. No longer does he need to restrict himself to slower and less accurate methods involving logarithmic tables and the like. During this interval of years, the emphasis of textbooks on orbit computation has not wholly changed to meet the needs of students who have the machines available as a matter of course. Professor Herget's book, "The Computation of Orbits," aims at presenting orbit computational methods couched in a form explicitly adapted to the small, desk-type calculators of the Fridén or Marchant type.

The volume under review has been developed from the courses in orbit computing given by the author over a period of years. It is obvious that such a work must be followed literally number by number by the student in carrying out the successive steps leading to the orbital elements of a minor planet or a comet.

As the author points out in his preface, emphasis has been placed at first on the minor planets. The student requires less of a theoretical background for computing the orbit of such an object and the solution is more readily obtained than would be a cometary orbit. Herget also points out the immense amount of work needing to be done on the orbits of these small members of the solar system.

In order to introduce the student to the methods of numerical integration and differentiation, the book begins with a chapter on the Calculus of Finite Differences. Thereafter follow chapters on Problems of Spherical Astronomy and The Problem of Two Bodies. In these chapters the basic reference systems on the celestial sphere are discussed, together with Kepler's laws of planetary motion and the definitions of the orbital elements. The author has not hesitated to use vector notation and methods where he feels they may result in a more elegant presentation of the material. In the opinion of the reviewer, this use of a somewhat more advanced technique, where desirable, is commendable provided the student takes the time to verify for himself the relationship of the vector method to his past mathematical experience.

Chapters relating to the main problem of determining orbital elements from observational data follow the introductory material. The methods of LaPlace and of Gauss and Olbers are discussed in detail with examples to illustrate the methods.

The book concludes with three chapters dealing with the Improvement of the Orbit, Special Perturbations, and Hansen's Method of General Perturbations.

Undoubtedly the book will fill the need for a moderately comprehensive course in orbit computation. The reviewer feels that its "teachability" may not be all that could be desired, but such additional explanations as are needed can be supplied by the instructor. The reviewer feels, in particular, that a somewhat more thorough understanding of the coordinate system would be gained by the student if Chapter 2 had been a little more detailed. Much depends on the maturity of the student when he undertakes the study of orbit work. Obviously, detailed study of the examples and actual computation of an orbit under guidance are the means of mastery of this fascinating part of mathematical astronomy. The author has made a noteworthy contribution to the astronomical literature in a field in which he is a recognized master.

S. W. McCuskey.

Case Institute of Technology, Cleveland, O.

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